DRDC Toronto CR 2008-115

Evaluation of a Shoulder Fragmentation Protection Brassard Design

By:

Paul G. Santos Vilhena, Chris Ste-Croix and Harry A. Angel,

Human*systems*® Incorporated
111 Farquhar St., 2nd floor
Guelph, ON N1H 3N4

Project Manager:
Harry A. Angel
519-836-5911

PWGSC Contract No. W7711-067989/001/TOR
Call-up No. 7989-07

On behalf of
DEPARTMENT OF NATIONAL DEFENCE

As represented by
Defence Research and Development Canada
1133 Sheppard Avenue West
North York, Ontario.

DRDC Toronto Scientific Authority:
Captain Philip Snow
(416) 635-2000 x3215

March 2008

Principal Author

//original signed//

Capt Philip Snow

Project Officer, Soldier Systems Integration Group, DRDC Toronto

Approved by

//original signed//

Dr. Justin Hollands

Head Human Systems Integration Section, DRDC Toronto

Approved for release by

//original signed//

Kim Wulterkens

For Document Review and Library Committee, DRDC Toronto

Sponsored by: Directorate of Land Requirements (DLR) 5, NDHQ, 101 Colonel By Drive, Ottawa, Ontario, K1A 0K2

Abstract

A fit and confirmatory design trial was conducted at Canadian Forces Base Petawawa May 28 to June 1 2007 to evaluate the differences between the current shoulder cap and brassard shoulder fragmentation protection designs. Twenty-five regular force personnel from 3rd Royal Canadian Regiment and 2nd Field Ambulance were required to undertake a battery of human factors tests while wearing the current shoulder cap and brassard conditions in a balanced, repeated measures design. A progressive four-day testing protocol was used, from static anthropometric measurements, to live fire, to dynamic discrete military activities tests, and finally dynamic military battle task tests. Evaluations included live fire range, obstacle course, mounted fighting task, dismounted fire and movement, FIBUA, and compatibility testing. Participants rated the designs in terms of manoeuvrability, ease, stability, compatibility, and comfort. Data collection included live fire target performance, acceptability ratings after each task, thermal discomfort ratings, physical discomfort ratings, fit sizing ratings, exit questionnaire acceptability ratings, and guided focus group discussions. Overall, no highly meaningful significant differences between the two conditions were seen in target engagement performance, compatibility, or task acceptability ratings for different tasks carried out in this trial. It is recommended that brassard should be implemented for improved shoulder fragmentation protection. Design improvements to the brassard design are discussed in the report.

Résumé

Un essai de confirmation et d'ajustement a été effectué à la Base des Forces canadiennes Petawawa du 28 mai au 1er juin 2007 afin d'évaluer les différences entre l'épaulière pare-éclats existante et les deux modèles de brassard. On a demandé à vingt-cinq membres de la force régulière du 3e Bataillon du Royal Canadian Regiment et de la 2e Ambulance de campagne de se soumettre à une batterie d'essais des facteurs humains en portant l'épaulière actuelle et les deux modèles de brassard selon une formule équilibrée de mesures répétées. On a utilisé un protocole d'essais progressifs de quatre jours, consistant en des mesures anthropométriques statiques, des essais de tir réel, des essais dynamiques de différentes activités militaires et enfin, des essais dynamiques de tâches militaires au combat. Les évaluations ont compris des essais de tir réel, le parcours du combattant, des tâches de combat embarqué, des essais de tir à pied et des déplacements, des essais de combat dans les zones bâties, et, enfin, des essais de compatibilité. Les participants ont coté les modèles sur les plans de la maniabilité, de l'aisance, de la stabilité, de la compatibilité et du confort. Les données recueillies englobaient les mesures du rendement pendant les essais de tir réel, les cotes d'acceptabilité après chaque tâche, les cotes d'inconfort thermique et physique, les cotes d'évaluation de l'ajustement et les cotes d'acceptabilité selon le questionnaire de départ et les discussions dirigées. Dans l'ensemble, aucune différence significative n'a été constatée entre les cotes attribuées aux deux modèles de brassard sur le plan du rendement sur le champ de tir, de la compatibilité ou de l'acceptabilité pour l'exécution des tâches. Il est recommandé que le brassard soit utilisé pour améliorer la protection de l'épaule contre les éclats. Des améliorations de la conception du brassard sont présentées ci-après.

Executive Summary

A fit and confirmatory design trial was conducted at Canadian Forces Bases Petawawa May 28 to June 1 2007 to evaluate the differences between the current shoulder cap and brassard shoulder fragmentation protection designs. Twenty-five regular force personnel (22 males and three females) from 3rd Royal Canadian Regiment and 2nd Field Ambulance were required to undertake a battery of human factors tests while wearing the current shoulder cap and brassard conditions in a balanced, repeated measures design. The participants' mean length of service in the regular forces was 2.6 years. Most (19) Participants had no operational experience.

A progressive testing protocol was used, from static anthropometric measurements, to live fire range, to dynamic discrete military activities tests, and finally dynamic military battle task tests. Day 1 consisted of anthropometric measurements. Day 2 included live fire range and vehicle compatibility. Days 3 and 4 involved an obstacle course, mounted fighting task, dismounted fire and movement, FIBUA, and compatibility testing. Data collection included live fire target performance, acceptability ratings after each task, thermal discomfort ratings, physical discomfort ratings, fit sizing ratings, and exit questionnaire acceptability ratings. Following the completion of all tasks for both designs, participants took part in a guided focus group.

The participants in this trial represented a large portion of the Canadian Forces (CF) population. The male participants represented almost the entire CF population with respect to the anthropometric measurements taken. The regular sized brassard is able to accommodate about half of that population while the large brassard is able to accommodate the other half. The females that participated in this experiment represented the 10th to the 55th percentile of the female CF population.

The overall performance of the brassard was very good. A large number of participants mentioned that they did not even notice a difference between the brassard and the current in-service shoulder caps. Soldiers also noted that with the added protection value of the brassard, it is a superior choice than the current shoulder caps.

In terms of shoulder ranges of motion, there were not any significant differences between the brassard and shoulder caps. Compared to the current in-service shoulder caps, the brassard performed favourably in all the compatibility assessments. There were slight advantages of the shoulder caps over the brassard with regards to chaffing and thermal comfort during the fire and movement task. Even though there were significant differences between the shoulder caps and brassard with respect to chaffing and thermal comfort, the brassard was still rated "barely acceptable" or higher. There was also an issue with the brassard compatibility with the LAV III; however, this issue is common even with shoulder caps. Participants preferred the brassard to the shoulder caps for getting into and out of the hatches because it fit closer to the arm and it moved more fluidly with the arm than the shoulder caps.

At the end of each day, the participants completed a daily exit questionnaire to reflect a single day's use of either the brassard or shoulder caps. Although generally differences were not statistically significant, the brassard typically outperformed the shoulder caps. The brassard was considered superior in coverage of the upper arm and shoulder due to the brassard's increased coverage design. The shoulder caps were preferred in areas such as thermal comfort and ease of attachment and removing. The focus group discussion revealed the participants unanimous preference for the brassard over the shoulder caps.

Recommended design changes to the brassard were also discussed in the focus group. Participants suggested several design improvements as a way forward on the current brassard design. Participants preferred the buckle be moved to a padded area with elastic bicep strap and ability for extra strap material to be strapped away by Velcro. Furthermore, participants wanted changes to current snap design to pull away dot snap in order to minimize snap accidental release issues. A Further design change brought up during the focus group was the pen pocket/glow stick holder be moved closer to front shoulder area in orientation of pocket and lower in order to improve access to pocket.

Sommaire

Un essai de confirmation et d'ajustement a été effectué à la Base des Forces canadiennes Petawawa du 28 mai au 1er juin 2007 afin d'évaluer les différences entre l'épaulière pare-éclats existante et les deux modèles de brassard. On a demandé à vingt-cinq membres de la force régulière du 3e Bataillon du Royal Canadian Regiment et de la 2e Ambulance de campagne de se soumettre à une batterie d'essais des facteurs humains en portant l'épaulière actuelle et les deux modèles de brassard selon une formule équilibrée de mesures répétées. La moyenne d'années de service des participants dans la force régulière était de 2,6 années. La plupart des participants (19) n'avait aucune expérience opérationnelle.

On a utilisé un protocole d'essais progressifs consistant en des mesures anthropométriques statiques, des essais de tir réel, des essais dynamiques de différentes activités militaires et enfin, des essais dynamiques de tâches militaires au combat. Le jour 1 a été consacré aux mesures anthropométriques et le jour 2, aux essais de tir réel et à la compatibilité avec le véhicule. Au cours des jours 3 et 4, les participants ont été soumis à un parcours du combattant, à des essais de combat embarqué, à des essais de tir à pied et de déplacement, à des essais de combat dans des zones bâties et enfin, à des essais de compatibilité. Les données recueillies englobaient des mesures du rendement pendant les essais de tir réel, les cotes d'acceptabilité après chaque tâche, les cotes d'inconfort thermique et physique, les cotes d'évaluation de l'ajustement et enfin, les cotes d'acceptabilité selon le questionnaire de départ. Après avoir exécuté toutes les tâches en portant les deux modèles, les participants ont pris part à un groupe de discussion dirigé.

Les participants à cet essai constituaient un échantillon représentatif des membres des Forces canadiennes (FC), les hommes représentaient presque l'ensemble des membres des FC en ce qui a trait aux mesures anthropométriques prises. Le brassard de taille moyenne conviendrait à environ la moitié des membres, et le brassard de grande taille, à l'autre moitié. Les participantes aux essais représentaient entre le 10e et le 55e percentile des membres féminins des FC.

Le rendement global du brassard a été jugé très bon. Un grand nombre de participants ont mentionné qu'ils n'ont même pas remarqué de différence entre le brassard et les épaulières présentement utilisées. Les soldats ont également fait remarquer que, compte tenu du surplus de protection qu'offre le brassard, il représente une amélioration par rapport aux épaulières.

En ce qui concerne la portée du mouvement de l'épaule, aucune différence importante n'a été perçue entre le brassard et les épaulières. Par rapport aux épaulières, le brassard a reçu une bonne cote dans toutes les évaluations de compatibilité. Sur les plans de l'irritation et du confort thermique, les épaulières présentaient un léger avantage par rapport au brassard durant le tir et les déplacements. Malgré ces différences, le brassard a quand même été obtenu une cote « passable » ou plus élevée. Il y avait également le problème de la compatibilité entre le brassard et le VBL III; toutefois, ce problème existe même avec les épaulières. Les participants ont préféré le brassard pour ce qui est d'entrer et de sortir des écoutilles parce qu'il est mieux ajusté au bras et qu'il suit mieux les mouvements du bras que les épaulières.

À la fin de chaque journée d'essai, les participants ont rempli un questionnaire de départ pour consigner leurs commentaires sur l'utilisation du brassard ou des épaulières. Bien que généralement, les différences ne soient pas statistiquement significatives, le brassard a surclassé les épaulières. Le brassard a été jugé supérieur pour protéger le bras et l'épaule en raison de la

conception plus enveloppante du brassard. Par contre, les épaulières ont reçu une meilleure cote sur le plan du confort thermique et de la facilité de fixation et d'enlèvement. La discussion a cependant révélé que les participants ont préféré unanimement le brassard aux épaulières.

Les participants ont également discuté des changements à apporter au brassard et en ont suggéré plusieurs. La boucle devrait être déplacée vers la zone matelassée, il devrait y avoir une sangle de biceps élastique et le surplus de sangle devrait être fixée au moyen d'un ruban autoagrippant. Il faudrait aussi modifier le modèle du bouton-pression afin qu'il soit plus solide et ne se détache par accident que dans de très rares occasions. Un autre changement proposé était de rapprocher le porte-plume/bâton luminescent vers l'avant de l'épaule. Il devrait être fixé dans le sens de la poche, mais plus bas afin d'améliorer l'accès à cette dernière.

Table of Contents

List of Figures

List of Tables

1 Introduction

A shoulder fragmentation protection brassard is being introduced into the Canadian Forces (CF) to provide soldiers with increased protection – see Figure 1. It is to be worn as part of the current Clothe-The-Soldier (CTS) Fragmentation Protection Vest (FPV) for troops deploying on operations and for pre-deployment training. The anti-fragmentation brassard will provide improved deltoid, upper arm, and upper body protection from blast and fragmentation effects. The recent trend in Improvised Explosive Device (IED) attacks, particularly from the side, would indicate that increased protection of the side and exposed extremities would reduce soldier exposure to blast effects (Armed Forces Institute of Pathology 2005). Additionally, the brassard will provide increased options to attach combat identification accessories such as the TAG-IR personal beacon, flags, and patches.

Figure 1: Canadian Forces Fragmentation Protection Vest and Tactical Assault Vest with Prototype Brassard

The shoulder fragmentation protection brassard is designed to attach in a similar way as the existing shoulder caps of the FPV. The brassard was designed to minimize any impediment to shoulder movement and to avoid snagging during mounted operations. The brassard also incorporates a utility pocket and hook and loop pile for the attachment of patches. The anti-fragmentation protection of the brassard is to the same level as provided by the remainder of the FPV. Initially a single size ambidextrous design was developed with the aim of hastening procurement and implementing a non-complex solution; however, further investigation suggests that multiple sizes may be required to accommodate all soldiers. As a result, two new brassard sizes have been developed for user evaluation. Feedback from the evaluation of the three sizes of brassards was incorporated into the fielding of the final design to be included in the personal protective ensemble (PPE).

2 Aim

The aim of this trial was to determine if the current brassard sizes adequately covered the entire range of upper arm sizes of Canadian Forces (CF) Land personnel, and determine the functionality of the brassard, the performance decrement (if any) of brassard, soldier acceptance of brassard, and functionality of the utility pocket designs.

This page intentionally left blank.

3 Method

3.1 Overview

A four day fit and confirmatory design trial was conducted at Canadian Forces Bases (CFB) Petawawa from May 28 to June 1, 2007. Twenty-eight participants passed through brassard fit and anthropometry stands. Upon the completion of the fit and anthropometry stands, three-days of confirmatory field tests were undertaken to determine the impact of the brassard on soldier tasks. Twenty-three regular force personnel were required to undertake a battery of human factors tests while wearing the current shoulder cap or the new brassard in a repeated measures design. During each test, the order of conditions was balanced among participants. Human factors tests included assessments of fit, adjustability, accessibility, range of motion, performance of select battle tasks, and equipment, vehicle and clothing compatibility. Data collection included anthropometric measurements, range of motion measurements, questionnaires, focus groups, live fire performance measures, and Human Factors (HF) observer assessments. Methods are detailed in subsequent sections.

3.2 Shoulder Protection Test Conditions

The two shoulder protection designs were tested in this trial with the current FPV. The current shoulder cap fragmentation protection design (see Figure 2) and the new shoulder fragmentation protection brassard with two pocket designs (see Figure 3 and Figure 4) were tested separately. The brassard design has been produced in three sizes (short, regular and tall). The brassard is attached to the top of the shoulder using the Gen III FPV shoulder strap attachment point. The upper half of the brassard has loops that snap into the Gen III FPV using the shoulder cap snap fastening points. The brassard also had either a buckle strap loop or a Velcro strap loop to retain the brassard on the upper arm.

Figure 2: Current Shoulder Cap

Figure 3: Brassard with Angled Pocket and Buckle Strap Loop Design

Figure 4: Brassard with Straight Pocket and Velcro Strap Loop Design

3.3 Protocol

A progressive testing protocol was employed in the confirmatory trial. The tests progressed from static indoor test stands in stage one, to outdoor dynamic test stands in stages two, three, and four. The following figure describes the progressive testing stages – see Figure 5.

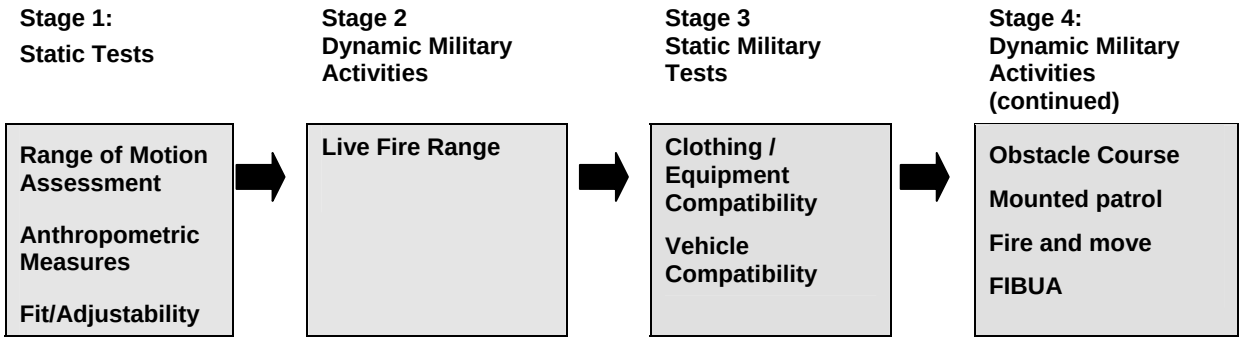


Figure 5: Progressive Testing Protocol

Stage two was completed on day two, with each participant completing the live fire range while wearing the shoulder caps and the brassard. Stages three and four were completed concurrently during days three and four of the trial. Participants evaluated either the brassard or the shoulder

caps on day three and switched to the other (brassard or shoulder caps) on day four. This way each participant completed stage three and four while wearing both the shoulder caps and brassard.

Day1 (Stage 1): Participants had anthropometric measurements taken by researchers and based on anthropometric data the researchers assigned one of three brassard sizes (tall, regular, or short). A fit assessment was then carried out to assess protective coverage (see Figure 6) and a fit questionnaire was completed.

Figure 6: Protective Coverage Assessment

Day 2 (Stage 2 and 3): The compatibility of the brassard with weapons was tested on a live fire range – see Figure 7. Participants were given a limited time to acquire and engage the targets. Range scoring was recorded and compared to scores while the participants were wearing the current in-service shoulder caps. Following the live fire exercise, participants completed the C7 live fire questionnaire.

Figure 7: C7 Rifle Range

Figure 8: Vehicle Compatibility

Day 3 and 4 (Stage 3 and 4): The next two days assessed the compatibility of both shoulder fragmentation protection designs with vehicles – see Figure 8 (LAV III, G-Wagon, and civilian vehicle inspection), weapons (C7, C9, C6, grenades, M72, and Carl Gustav), and clothing (small pack and large pack). Researchers recorded compatibility acceptance ratings for both the brassard and shoulder caps with each piece of equipment.

The participants also completed other tests that incorporated more traditional military activities. The obstacle course evaluated the stability of the brassard and shoulder caps during typical field movements - see Figure 9. Participants were instructed to perform manoeuvres so that the shoulder would be oriented in a wide range of postures. Participants then completed an obstacle course task questionnaire.

Figure 9: Obstacle Course

Infantry battle tasks, which combine many infantry activities and skills into high fidelity simulations of combat missions, were also completed. Daylight mounted patrols (see Figure 10), followed by dismounted fire and movement (see Figure 11), and FIBUA attack (see Figure 12) were performed to simulate the movement demands of patrolling and contact engagements with an enemy force. Given the importance of shoulder movement, compatibility with section attacks and FIBUA warfare was simulated and assessed. Task questionnaires were filled out after the conclusion of the FIBUA attack.

Figure 10: Mounted Section Attacks

Figure 11: Dismounted Section Fire and Movement Attacks

Figure 12: Dismounted Section FIBUA

At the conclusion of day four, participants took part in a guided focus group to discuss the issues of the brassard and shoulder cap designs. Researchers recorded the answers to the open discussion.

3.4 Participants

A total of twenty-eight participants were recruited from the CF, mostly from 3rd Royal Canadian Regiment (RCR) and 2nd Field Ambulance. Twenty-five of the participants commenced the full 4 day trial with twenty-one participants completing the entire trial. Some participants had to withdraw from the trial because of other training and operational requirements. The mean age of the participants was 25.1 years (SD=4.2, max=33, min=21). The mean length of service in the regular forces for the participants was 2.6 years (SD=2.1, max=10, min=1 month, mode=0). Most (19) participants had no operational experience (max=3, min=0).

3.5 Data Measures

Anthropometry: Participants were measured for various anthropometric measurements. The measurements were used to identify what sizes of brassards fit what percentage of the population. The measurements were also used to validate that this study had a wide range of participants based on anthropometrics.

Area of Coverage: Participants were measured for shoulder overlap and upper arm coverage measurements. The measurements were used to evaluate the brassard fit and estimate the coverage by the brassard of the upper arm area.

Range of Motion: Shoulder ranges of motion were taken for each participant with brassards and with the current in-service shoulder caps. This data was used to identify any deficiencies in shoulder range of motion caused by the proposed brassard.

Questionnaires: Participants completed a number of questionnaires that were intended to reveal their perceptions about the shoulder fragmentation protection brassard design.

Participants were asked to complete the fit questionnaire. Using a 7-point scale, where 1 was *completely unacceptable*, 4 was b*orderline*, and 7 *completely acceptable*; participants rated the acceptability for a number of different shoulder protection issues of the assigned brassard size. Participants were also asked on the fit questionnaire to complete fit sizing questions, using a 5-point fit sizing scale, where 1 was *short small tight*, 3 was *normal*, and 5 was *long large loose.*

Participants were also asked to complete several task compatibility, feature, daily exit, and exit questionnaires at different points of the trial. Using the same 7-point scale of acceptability, participants rated both current shoulder cap and brassard design on a wide range of issues.

Furthermore, participants were asked to complete a discomfort questionnaire. Using a 5-point thermal discomfort scale, where 1 was neutral, 3 was warm and 5 was very hot, participants rated the thermal discomfort of the brassard design. Finally, using a 5-point physical discomfort scale, where 1 was neutral, 3 was noticeable discomfort and 5 was extreme pain, participants rated physical discomfort of the brassard design with the current fragmentation protective vest.

All questionnaires were completed by each participant twice, once while wearing the brassard and once while wearing shoulder caps. The comparison of the results of these questionnaires was used in the analysis.

Focus Group: Following the completion of the trial participants took part in a guided focus group. They discussed different issues of brassard design in an effort to collect information that can be used in the improvement of the current brassard design.

3.6 Data

Data collection focused on the following HF requirements as detailed below. The order in which trial participants were exposed to either current shoulder cap or new brassard design was balanced.

- Fit/Adjustability;
- Anthropometry;
- Area of Coverage;
- Range of Motion;
- Clothing/Equipment Compatibility;
- Vehicle Compatibility;
- Activity Performance;
- Battle Task Performance;
- Feature Acceptability;
- Physical Discomfort;
- Thermal Discomfort; and
- Overall Acceptability

3.6.1 Fit/Adjustability

Participants were required to find a properly fit brassard. The participants were given a brassard and were required to perform selected movements. Upon completion of adjustment and fitting, participants completed a brassard fitting questionnaire. Based on the results of this questionnaire and ballistic coverage assessment the participant was either fitted for another size brassard or kept the initial brassard. HF observers evaluated the ease of adjustment and the acceptability of the final fit.

3.6.2 Anthropometry

Anthropometric measurements were taken from each soldier prior to the start of the trial. There were a total of five anthropometric measurements taken for each soldier (2 length measurements and 3 circumference measurements). The length measurements were taken using an anthropometer and the circumference measurements were taken using a tape measure. Each anthropometric measurement was recorded three times and the average of the three was used. A detailed description of how the measurements were taken is presented below:

- **Acromion-Radiale Length**- The distance between the acromion landmark on the tip of the right shoulder and the radiale landmark on the right elbow is measured with a beam caliper held parallel to the long axis of the arm. The subject stands erect. The shoulders and upper extremities are relaxed with the palms facing the thighs;
- **Shoulder-Elbow Length**- The distance between the acromion landmark on the tip of the right shoulder and the olecranon landmark on the bottom of the right elbow is measured with a beam caliper parallel to the long axis of the upper arm. The subject stands with the

right upper arm hanging at the side and the elbow flexed 90 degrees. The hand is straight and the palm faces inward;

- **Scye Circumference-** The vertical circumference of the right upper arm (scye) is measured with a tape passing through the armpit and over the acromion landmark on the tip of the shoulder. The subject stands erect looking straight ahead. The shoulders and upper extremities are relaxed with the palms facing the thighs;
- **Biceps Circumference, Contracted-** The circumference of the right upper arm around the flexed biceps muscle is measured with a tape held perpendicular to the long axis of the upper arm. The subject stands with the upper arm extended horizontally and the elbow flexed 90 degrees. The fist is clenched and held facing the head, and the subject exerts maximum effort in "making a muscle"; and
- **Elbow Circumference-** The circumference of the right elbow in a plane perpendicular to the long axis of the arm is measured with a tape passing around the elbow at the level of the olecranon-center landmark. The subject stands with the arm straight and slightly away from the side (approximately 30º).

3.6.3 Area coverage

After fitting, participants were measured for shoulder overlap and upper arm coverage. The measurements were used to identify proper fit of brassard and estimate the coverage by the brassard of the upper arm area. The measurements were used to estimate proper fit by comparing the shoulder overlap and upper arm coverage in order insure that shoulder brassard could adjust to cover most of the upper arm area. The following area of coverage measurements were used for the brassard design.

- **Shoulder Overlap Distance:** Distance from fragmentation vest outer edge at shoulder and brassard shoulder overlap.
- **Upper Arm Coverage Distance**: Distance from bottom of the brassard to the elbow crease. The elbow crease is the skin crease on the inside of the elbow joint when the elbow is flexed 90 degrees.

3.6.4 Range of Motion

The following ranges of motion were measured for both the brassard and shoulder cap designs. The shoulder cap measures were used as a baseline to which the brassard measurements were compared.

- **Shoulder Abduction:** Standing with their backs to a wall, participants raised each straight arm laterally in the frontal plane until they perceive resistance. The HF observer measured the angle of the upper arm, relative to the vertical, at the point of resistance; and
- **Medial Shoulder Flexion:** Standing, bent forward at the waist with the back parallel to the floor, participants moved each straight arm medially across their chest until they perceive resistance. The HF observer measured the angle of the upper arm, relative to the vertical, at the point of resistance.

3.6.5 Range Firing

Using a small arms range, participants performed the following modified personal weapons test serials with the C7A1 rifle.

Serial 1 and 2: Grouping and zeroing at 100m (prone).

Serial 3 to 7: Application and snap shoots (100-300m)

Serial 8: Fire and movement starting in the prone position at 400m.

a) Double to 300m (prone unsupported, two Figure 11 targets).
b) Double to 200m (kneeling supported, two Figure 11 targets).
c) Double to 100m (prone unsupported, two Figure 11 targets)
d) Walk to 50m (standing, snap shooting, one Figure 11 target).

Each participant undertook range firing in each condition. Participant performance was evaluated using target range scoring. Participants were required to rate the performance, acceptability, and comfort of each condition. HF observers evaluated compatibility issues associated with firing. At the completion of range firing, participants were required to complete a task questionnaire for each condition.

3.6.6 Clothing/Equipment Compatibility

Compatibility with clothing and equipment was evaluated at four static test stands. Participants were divided into four groups to perform the required drills and HF observers collected participant ratings on compatibility. Participants were encouraged to adjust and configure their fragmentation vest and brassard to the best of their ability to accommodate the test clothing and equipment prior to each test. Each participant was evaluated separately while under the supervision of an HF observer.

The four static compatibility test stands comprised the following pieces of equipment:

Clothing: Small Pack System and Large Pack System (in one clothing stand)

Weapons: C7A1/A2 Rifle, C9A1 LMG, C6 MMG, M72 SRAAW, Carl Gustav, and Grenades (in three weapon stands)

Participants were required to rate the compatibility of both the brassard and shoulder caps with each of the selected weapons, equipment, and clothing at each test stand. HF observers measured clothing and equipment stand-off and noted instances of compatibility clash and difficulty.

3.6.7 Vehicle Compatibility

Test conditions were evaluated for compatibility with the Light Armoured Vehicle (LAV) III and G-wagon vehicles. Participants were divided into smaller groups to perform the required drills. Specific evaluations included:

a) Access/Egress: Participants were required to rate the ease of access and egress of vehicle hatches and doors. HF observers evaluated soldiers entering and exiting vehicles for any postural, range of movement, and vehicle obstruction effects.

b) Vehicle Operation: Participants were required to rate the estimated ease of driving the vehicle in each condition. HF observers evaluated participants during vehicle operation for any postural, range of movement, and crew station obstruction.

c) Air Sentry and Observer Tasks (where applicable): Participants were required to rate the estimated ease of performing air sentry tasks in the LAV III. HF observers evaluated participants during air sentry and observer tasks for any postural or range of movement obstructions.

d) **Commander and Gunner Tasks (where applicable):** Participants were required to rate the estimated ease of performing commander and gunner tasks in the LAV III. HF observers evaluated participants during commander and gunner tasks for any postural, range of movement, and crew station obstruction.

Participants were required to rate the compatibility of the test conditions noting restrictions on movements with each of the assigned vehicle. HF observers noted instances where certain tasks could not be performed due to the effects of the brassard or shoulder cap.

3.6.8 Activity Performance

Brassard effects on the performance of specific military combat and peacekeeping tasks were evaluated (obstacle course and civilian vehicle inspection).

a) **Obstacle Course:** The following obstacles were undertaken consecutively as part of single course (see Figure 13 through Figure 24). Subjective ratings by trial participants and performance timings were collected for each test. Participants performed these tests in their assigned fragmentation vest/fighting order/brassard conditions. At the completion of the obstacle course, participants were required to complete an obstacle course task questionnaire. For each obstacle, participants had to wear either the brassard or shoulder cap with FPV, CG634 helmet, TAV, and carry a C7 or C8.

- **Ladder Obstacle:** Ascend a 10m ladder, straddle and traverse the top bar, then descend the ladder to the ground;

Figure 13: Ladder Obstacle

- **Crawl Obstacle:** Perform a Leopard crawl while traversing a 10m low wire obstacle;

Figure 14: Crawl Obstacle

- **Low Wall Obstacle:** Run 3m and climb (unassisted) over a 1.5m high wall;

Figure 15: Low Wall Obstacle

- **High Wall Obstacle:** Run 3m and climb (assisted) over a 2.4m high wall;

Figure 16: High Wall Obstacle

- **Short Pit Obstacle:** Run up a 2m ramp and jump down into a sand pit ;

Figure 17: Short Pit Obstacle

- **Tall Pit Obstacle:** Run up a 3m ramp using a rope assist and jump down into a sand pit;

Figure 18: Tall Pit Obstacle

- **Over Under Obstacle:** Climb over and crawl under three successive metal bars mounted 0.5 and 1.0 meter from the ground; and

Figure 19: Over Under Obstacle

- **Fence Obstacle:** Ascend a 2m metal fence, straddle and traverse the top bar, then descend the metal fence to the ground;

Figure 20: Fence Obstacle

- **Mouse Hole Obstacle:** Crawl through a square, concrete mouse hole shaft for 1m.

Figure 21: Mouse Hole Obstacle

- **Wire Obstacle:** Step over five successive low wires mounted 0.5m above the ground;

Figure 22: Wire Obstacle

- **Irish Stones Obstacle:** Step on a series of successive stones placed in the ground; and

Figure 23: Irish Stones Obstacle

- **Balance Beam Obstacle:** Walk along a balance beam.

Figure 24: Balance Beam Obstacle

3.6.9 Battle Task Performance

Several combat activities were combined to form different battle tasks. The effects of the brassard on soldier performance were evaluated for three battle tasks: fire and movement, FIBUA, and

vehicle patrol. Participant performance ratings and HF observer assessments were collected during each task.

a) Vehicle Patrol: Participants completed a short vehicle patrol that ended in an ambush in a built up area. The patrol consisted of one LAV III and one G-wagon vehicle. Participants were required to engage targets with blanks and change magazines as they exited the vehicle and proceeded tactically through a wooded area engaging the enemy force. At the completion of vehicle patrol / ambush, participants quickly continued into a fire and movement task.

Participants were required to utilize one of the following crew stations per run:

- LAV III
  a. Driver (only used by qualified LAV III driver)
  b. Air sentry (all participants ran through air sentry crew station position) and
  c. Turret
     i. Crew commander (only used by qualified LAV III crew commander)and
     ii. Gunner (only used by qualified LAV III gunner)
- G-wagon
  a. Driver (only used by qualified G-wagon driver)
  b. Turret

b) Fire and Movement: Participants were required to engage in a section attack simulation. Participants rated their effectiveness in all conditions. HF observed the speed, agility, and postural effects of each condition.

Single sections performed the fire and movement test at a time. Enemy positions were simulated in a defensive position with cut outs, while the test sections perform standard skirmishing fire and movement to advance and assault the enemy position. All sections were issued blank ammunition. At the completion of each condition, participants were required to complete a task questionnaire.

c) FIBUA: Participants were required to engage in a house clearing simulation. Participants rated their effectiveness in all conditions. HF observers evaluated the speed, agility, accessibility and postural effects of each condition.

Two sections performed the house clearing drill at one time. Targets placed within the building simulated enemy positions. All sections were issued with Simunition. The attacking sections entered the building through a window and then clear the house, room to room, one floor at a time. Maximum use of ceiling and wall mouse holes were required. At the completion of each condition participants was required to complete a task questionnaire.

3.6.10 Feature Acceptability

At the end of the trial, participants were required to rate the acceptability of brassard and shoulder cap features such as attachment points, adjustment, and straps for functionality and durability. These features were discussed in detail during the exit focus group to identify problem areas and suggestions for improvement.

3.6.11 Physical Discomfort

At the conclusion of days 3 and 4 participants were required to complete a physical comfort questionnaire. This questionnaire was comprised of drawings of the front and back sides of the torso. Participants were required to indicate the body location and rate the extent of physical discomfort using the five point rating scale provided. Discomfort could include, but was not limited to, contact irritation or pressure points. HF staff investigated any reports of physical discomfort through photographs and interviews with affected participants.

Using a standard five-point rating scale of discomfort, where 1 was neutral, 3 was noticeable discomfort and 5 was extreme pain, participants rated the acceptability of physical comfort by location – see Figure 25.

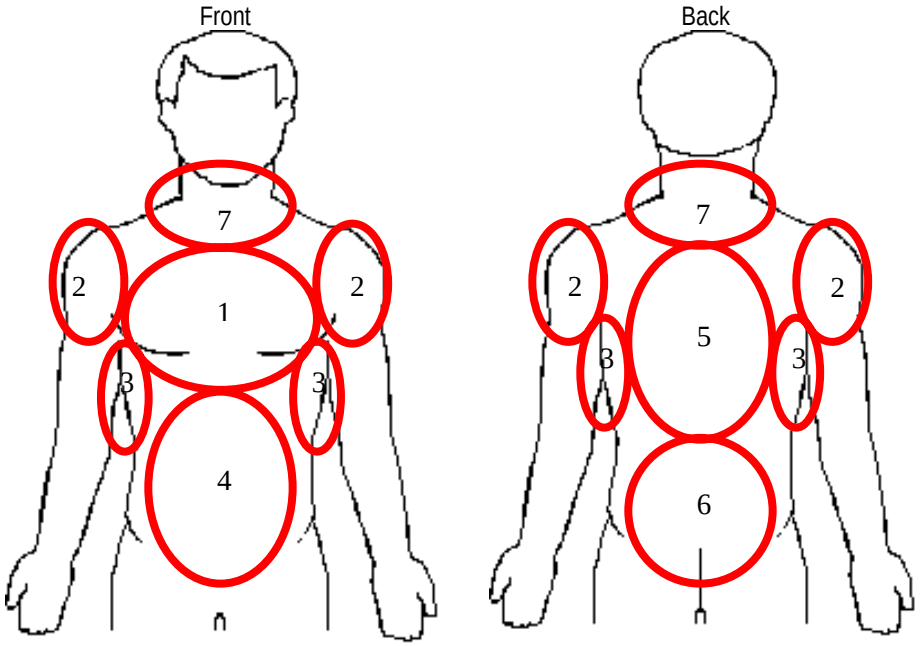


Figure 25: Physical Discomfort Locations

3.6.12 Thermal Discomfort

At the conclusion of days 3 and 4 participants were also required to complete a thermal comfort questionnaire. This questionnaire was comprised of drawings of the front and back sides of the torso. Participants were required to indicate the body location and rate the extent of thermal discomfort using the five point rating scale provided. Discomfort could include, but was not limited to, hot spots or chaffing. HF staff investigated any reports of thermal discomfort through photographs and interviews with affected participants.

Using a standard five-point rating scale of discomfort, where 1 was neutral, 3 was warm and 5 was very hot, participants rated thermal discomfort of brassard design by location – see Figure 25.

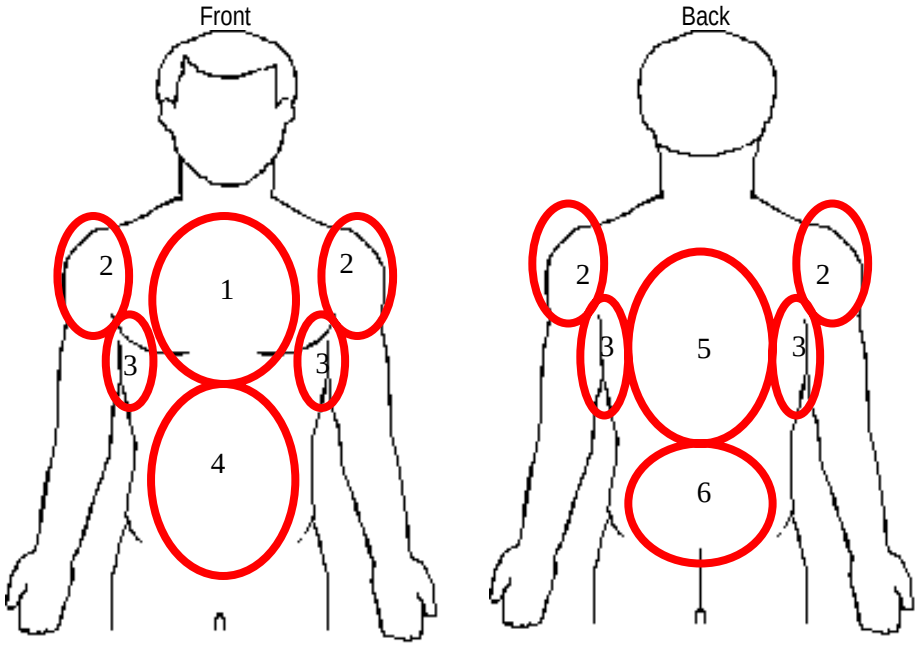


Figure 26: Thermal Discomfort Locations

3.6.13 Overall Acceptability

Participants were required to rate their overall acceptance of the brassard, including their perceived level of protection, wearability, and the general appearance of the garment, using an exit questionnaire.

3.7 Statistical Plan

The quantitative results of this evaluation were analyzed using parametric Analysis of Variance (ANOVA) methods. Qualitative results were analyzed using non-parametric methods. These methods included: Friedman Analysis of Variance (ANOVA) & Kendall Coefficient of Concordance analysis, and Chi-Square tests. Differences were identified at $p < 0.05$. The statistical plan was as follows:

Table 1: Statistical Plan

Data Source	Data Type	Analysis Type
Range Of Motion	ROM Measurement	ANOVA for repeated measures: - Shoulder ROM (2) - Target (2)
C7/C8 Live Fire Range Questionnaire	Subjective task assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question: - Arm protection (2) - Criteria (39)
C7/C8 Live Fire Range	Engagement accuracy	ANOVA for overall range score: - Arm protection (2)
Mounted Section Crewman Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question: - Arm protection (2) - Criteria (35)
Dismounted Section Fire and Movement Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question: - Arm protection (2) - Criteria (37)
Dismounted Section FIBUA Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question: - Arm protection (2) - Criteria (32)
Obstacle Course Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question: - Arm protection (2) - Criteria (43)
Physical Discomfort Questionnaire	Subjective assessment by participant	Chi Square test for each region : - Arm protection (2) - Region (7)
Thermal Discomfort Questionnaire	Subjective assessment by participant	Chi Square test for each region : - Arm protection (2) - Region (7)
Daily Exit Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question: - Arm protection (2) - Criteria (46)
Final Exit Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question: - Arm protection (2) - Criteria (26)

Note 1: Variation of the sample size because some participants had to withdraw due to other training and operational requirements

Note 2: Missing data points for questionnaires because some participants did not complete questionnaires fully due to lack of experience to answer a question or forgetting to answer a question.

4 Results

In the following sections, means and standard deviations are presented for the anthropometric, area of coverage, range of motion, and questionnaire data. The questionnaires included participants' assessments of the following areas:

- Fit Assessment;
- Task Compatibility;
    - Individual Weapons and Equipment,
    - Live Fire,
    - Mounted Section Crewman Tasks,
    - Dismounted Section Fire and Movement Tasks,
    - Dismounted Section FIBUA Tasks and
    - Obstacle Course
- Features;
- Physical Discomfort;
- Thermal Discomfort;
- Daily Exit; and
- Final Exit.

At the end of each task, the participants either stated an acceptability rating or completed a questionnaire with regards to the trial condition (current in-service shoulder cap or brassard). Using the standard seven-point scale of acceptance, participants rated their condition in the context of the task. In addition to numerical ratings using the scale, participants were given the opportunity to make subjective comments. Following the completion of the each condition and both conditions, the researcher guided a focus group to generate discussion on different points of the brassard design.

Of the 25 participants initially recruited from the CF, only 21 participants completed the full 4-day fit and confirmatory trial because:

- Some participants had to withdraw due to other training and operational requirements; and
- Some participants did not complete questionnaires fully due to lack of experience to answer a question or forgetting to answer a question.

4.1 Anthropometric Measurements

At the beginning of the study anthropometric was data was collected for each participant. The anthropometric data collected was scye circumference, biceps circumference, elbow circumference, acromion-radiale length and shoulder-elbow length.

Participants were measured using a soft plastic tape measure. The mean values with standard deviation (SD) for anthropometric measurements and how the participants related to Land Forces (LF) anthropometric survey (Chamberland, Carrier, Forest, & Hachez, 1997) are shown below.

4.1.1 Scye Circumference

Each participant's scye circumference was measured 3 times. The average of the 3 measurements was used in the analysis. The male participants ranged in scye circumference from 398mm to 513mm which represents the 1st percentile male to the 97th percentile male. The female participants' scye circumference ranged from 373mm to 413mm incorporating the 5th percentile female to the 60th percentile female – see Table 2.

Table 2: Scye Circumference Measurements and Population Percentages

	Male (n=22)		Female (n=3)	
	Max	Min	Max	Min
Scye Circumference (mm)	513	398	413	373
Population Percentile	97	1	60	5

4.1.2 Biceps Circumference, Contracted

Each participant's biceps circumference while contracted was measured 3 times. The average of the 3 measurements was used in the analysis. The male participants ranged in biceps circumference from 287mm to 392mm which represents the 1st percentile male to the 90th percentile male. The female participants' biceps circumference ranged from 278mm to 312mm incorporating the 30th percentile female to the 65th percentile female – see Table 3.

Table 3: Biceps Circumference Measurements and Population Percentages

	Male (n=22)		Female (n=3)	
	Max	Min	Max	Min
Biceps Circumference, Flexed (mm)	392	287	312	278
Population Percentile	90	1	65	30

4.1.3 Elbow Circumference

Each participant's elbow circumference while contracted was measured 3 times. The average of the 3 measurements was used in the analysis. The male participants ranged in elbow circumference from 243mm to 298mm which represents the 1st percentile male to the 80th percentile male. The female participants' elbow circumference ranged from 218mm to 235mm incorporating the 2nd percentile female to the 25th percentile female – see Table 4.

Table 4: Elbow Circumference Measurements and Population Percentages

	Male (n=22)		Female (n=3)	
	Max	Min	Max	Min
Elbow Circumference (mm)	298	243	235	218
Population Percentile	80	1	25	2

4.1.4 Acromion-Radiale Length

Each participant's acromion-radiale length was measured 3 times. The average of the 3 measurements was used in the analysis. The male participants ranged in acromion-radiale length from 284mm to 383mm which represents the 1st percentile male to the 99th percentile male. The female participants' acromion-radiale length ranged from 278mm to 297mm incorporating the 1st percentile female to the 15th percentile female – see Table 5.

Table 5: Acromion-Radiale Length Measurements and Population Percentages

	Male (n=22)		Female (n=3)	
	Max	Min	Max	Min
Acromion-Radiale Length (mm)	383	284	297	277
Population Percentile	99	1	15	1

The maximum and minimum acromion-radiale length values of all the male soldiers were taken and divided into those that wore regular brassards and those that wore large brassards. Those that wore regular brassards had acromion-radiale length values that ranged from 284mm, representing the 1st percentile male, to 329mm, representing the 20th percentile male. The soldiers that wore the large brassard had acromion-radiale lengths that ranged from 319mm, representing the 10th percentile male, to 383mm, representing the 99th percentile male – see Table 6. According to these results the regular brassard will accommodate the 1st percentile male to the 20th percentile male and the large brassard will accommodate the rest of the male soldier population.

Table 6: Acromion-Radiale Length Measurements for Males by Brassard Size

	Max (mm)	Percentile	Min (mm)	Percentile
Regular Brassard	329	20	284	1
Large Brassard	383	99	319	10

4.1.5 Shoulder-Elbow Length

Each participant's shoulder-elbow length was measured 3 times. The average of the 3 measurements was used in the analysis. The male participants ranged in shoulder-elbow length from 334mm to 426mm which represents the 5th percentile male to the 99th percentile male. The female participants' shoulder-elbow length ranged from 312mm to 333mm incorporating the 10th percentile female to the 55th percentile female – see Table 7.

Table 7: Shoulder-Elbow Length Measurements and Population Percentages

	Male (n=22)		Female (n=3)	
	Max	Min	Max	Min

Shoulder-Elbow Length (mm)	426	334	333	312
Population Percentile	99	5	55	10

The maximum and minimum shoulder-elbow length values of all the male soldiers were taken and divided into those that wore regular brassards and those that wore large brassards. Those that wore regular brassards had shoulder-elbow length values that ranged from 334mm, representing the 5th percentile male, to 373mm, representing the 70th percentile male. The soldiers that wore the large brassard had shoulder-elbow lengths that ranged from 367mm, representing the 60th percentile male, to 426mm, representing the 99th percentile male – see Table 8. According to these results the regular brassard will accommodate the 5th percentile male to the 70th percentile male and the large brassard will accommodate the rest of the male soldier population. This measurement gives a better indication of what size of brassard fits which percentage of soldiers. Since, the objective of the brassard is to cover the shoulder to the elbow without causing any buckling at the elbow this measurement is superior to the acromion-radiale value. Based on these results it can suggested that soldiers up to approximately the 60th percentile will wear a regular brassard and those that are at the 70th percentile and above will wear the large brassard. Those that fall between the 60th and 70th percentiles are able to wear either the large or regular brassard depending on their preference.

Table 8: Shoulder-Elbow Length Measurements for Males by Brassard Size

	Max (mm)	Percentile	Min (mm)	Percentile
Regular Brassard	373	70	334	5
Large Brassard	426	99	367	60

4.2 Range of Motion

All participants were measured for shoulder range of motion (flexion and abduction) while wearing the shoulder caps and while wearing the brassard. While wearing the shoulder caps the average shoulder abduction was 151.90º and shoulder flexion was 27.70º. While wearing the brassards the average shoulder abduction was constant around 151.03º while the range of shoulder flexion increased to an average of 27.9º – see Table 9.

Table 9: Shoulder ROM while Wearing Shoulder Caps or Brassards

	Shoulder Caps Mean (S.D.)	Brassard Mean (S.D.)	Difference Mean (S.D.)
Abduction (degrees)	151.90 (7.9)	151.03 (9.9)	0.87
Flexion (degrees)	24.70 (8.0)	27.90 (8.8)	-3.20

A repeated measures ANOVA was used to identify any significant differences in shoulder range of motion between the shoulder caps and the brassard. The results of the ANOVA indicate that there were no significant differences between the shoulder caps and the brassard for shoulder abduction and shoulder flexion.

4.3 Fit Assessment

On the first day each participant completed a fitting assessment to evaluate fit of the brassard and to ensure that proper size was used by participant. Participants used a standard seven-point scale of acceptance to rate each question, with completely unacceptable at 1, borderline at 4, and

completely acceptable at 7. A standard five point scale of fit sizing was also used to rate fit, with short-small-tight at 1, normal at 3 and long-large-loose at 5.

All brassard fit questions were rated at least "barely acceptable" and all fit was rated "normal" for the mean values. The mean values with standard deviation (S.D.) for acceptance are shown in Table 10.

Table 10: Fit Acceptability Results

7-point scale acceptability scale (n=25)	Mean (S.D.)
Brassard length	5.6 (0.9)
Brassard girth	5.3 (1.2)
Final fit	5.5 (0.7)
Ease of adjustment	5.3 (1.0)
Ease of donning	5.2 (1.1)
Ease of doffing	5.4 (1.1)
Ballistic coverage - shoulders	5.8 (0.8)
Ballistic coverage - upper arms	5.5 (1.1)
5-point fit sizing scale (n=24)	Mean (S.D.)
Brassard length – fit sizing	3.1 (0.3)
Brassard girth – fit sizing	3.2 (0.7)
Final fit – fit sizing	3.1 (0.4)

4.4 Area of Coverage

Each participant's shoulder-overlap distance between the brassard and FPV were measured. The desired amount of overlap was approximately 6 cm. The average amount of overlap across all sizes of brassards was approximately 8.08 (SD=1.47) cm, which was greater than the desired amount of overlap – see Table 11. When the amount of shoulder overlap was separated based on size of brassard, all sizes of brassards provided a sufficient amount of overlap at the shoulder. Based on the participants of this trial and the brassard sizes issued, all participants had sufficient amount of overlap at the shoulder to provide adequate protection.

The distance between the bottom of the brassard to the bottom of the elbow was also measured to indicate the amount of upper arm/elbow that is not protected by the brassard – shown on the right side of Table 11. On average there was 13.73 (SD=2.31)cm left unprotected by the brassard. Across all size ranges the maximum amount of area left unprotected was 19.5 cm. There is a minimum amount of unprotected area that is required to prevent any clash of the brassard with the forearm/ elbow during normal arm movements. Based on our participants and the size of brassard issued, it can be concluded that the brassard is able to leave enough unprotected areas on the upper arm/elbow to prevent any clash, as well as, provide sufficient upper arm protection.

Table 11: Area of Coverage Provided by the Brassard

	Shoulder Coverage (n=25)			Elbow Coverage (n=25)		
	Max	Min	Mean (S.D.)	Max	Min	Mean (S.D.)
Small (cm)	9.25	8.00	8.67 (0.82)	11.75	10.00	11.00 (1.22)
Regular (cm)	10.00	5.25	7.48 (1.46)	15.50	10.50	13.33 (1.65)
Large (cm)	11.00	7.00	8.64 (1.38)	19.50	11.50	14.95 (2.45)
Mean (cm)	-	-	8.08 (1.47)	-	-	13.73 (2.31)

4.5 Compatibility

The compatibility section prompted participants to give an acceptability rating of in-service shoulder cap and brassard with current PPE for a wide range of different issues. The acceptability rating was given on a scale of 1 to 7, with completely unacceptable at 1, borderline at 4, and completely acceptable at 7.

This provided the participants the opportunity to convey opinions regarding weapons, equipment, live fire, mounted section crewman, dismounted section fire and move, dismounted section FIBUA and obstacle course task compatibility. The average acceptability ratings with standard deviations are presented in below. Shading indicates unacceptable (less than 4) mean values.

The mean results indicated that generally both designs are rated as being acceptable and have similar ratings across the majority of the questions.

4.5.1 Individual Weapons, Equipment and Vehicle Inspection

Participants were asked to rate the compatibility of both the shoulder caps and the brassards with the weapons C6, C9, and C7 (prone, kneeling, and standing), grenade (prone, kneeling), M72, Carl G, small pack, large pack and vehicle inspection. Both the shoulder caps and brassards were rated as being between 'barely acceptable' and 'reasonably acceptable' for weapon and equipment acceptability questions mean values – see Table 12. The results indicate that brassards were of similar acceptability to the shoulder cap design for all the different compatibility criteria.

Table 12: Weapon and Equipment Compatibility Results

	Shoulder Caps (n=22) Mean (S.D.)	Brassard (n=22) Mean (S.D.)
C6	6.2 (0.8)	6.0 (0.9)
C9	6.3 (0.9)	6.0 (1.0)
C7 Prone	6.5 (0.6)	6.6 (0.6)
C7 Kneeling	6.5 (0.8)	6.6 (0.6)
C7 Standing	6.4 (0.7)	6.7 (0.5)
Grenade Prone	6.0 (0.9)	5.9 (1.1)
Grenade Kneeling	6.2 (0.9)	6.3 (0.6)
M72	6.5 (0.5)	6.4 (0.6)
Carl G	6.3 (0.6)	6.6 (0.5)
Small Pack	6.0 (1.0)	6.4 (0.7)
Rucksack	5.8 (0.9)	6.0 (0.7)
Vehicle inspection	6.3 (0.8)	6.2 (0.7)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for weapon and equipment acceptability scores by weapon and equipment system. No significant preference was found for either the shoulder caps or brassards for weapon, equipment and vehicle inspection compatibility.

4.5.2 C7/C8 Live Fire Tasks

At the end of each live fire serial, participants completed a live fire questionnaire to evaluate ease of operation, compatibility, comfort, stability, protector adjustment, and overall field use ratings for either the brassard or shoulder cap. Participants used the standard seven-point scale of acceptance

to rate each question, with completely unacceptable at 1, borderline at 4, and completely acceptable at 7. The mean values with standard deviation (S.D.) for acceptance are shown below in Table 13. Range scores were collected to indicate the accuracy of live fire with each design - see Table 14.

Both the shoulder caps and brassards mean ratings were between ‘barely acceptable’ and ‘reasonably acceptable’ for ease of operation, compatibility, comfort, stability, protector adjustment, and overall field use question mean values.

Table 13: C7/C8 Live Fire Range Questionnaire Results

	Shoulder Caps (n=24) Mean (S.D.)	Brassard (n=24) Mean (S.D.)
Ease of Operation		
Running	6.1 (0.8)	6.1 (0.7)
Dropping to prone position	6.0 (0.7)	6.1 (0.7)
Adopting prone fire position	6.1 (0.8)	6.0 (1.1)
Adopting kneeling firing position	5.9 (0.8)	6.1 (0.7)
Adopting standing firing position	5.8 (0.9)	5.8 (1.1)
Sighting	5.9 (1.0)	6.0 (0.9)
Firing	6.1 (0.6)	6.0 (0.6)
Loading/unloading	6.1 (0.7)	6.0 (0.8)
Accessing mags	6.1 (0.7)	5.9 (0.9)
Standing up	6.1 (0.7)	6.1 (0.7)
Overall C7 Firing Task	6.2 (0.5)	6.0 (0.7)
Compatibility		
Frag Vest	5.9 (0.8)	6.0 (0.6)
Load Carriage	5.7 (1.0)	6.0 (0.8)
Helmet	6.0 (1.0)	6.0 (0.9)
Clothing	6.0 (0.7)	6.0 (0.8)
Gloves	6.2 (0.7)	6.0 (0.9)
Weapons	6.2 (0.8)	5.9 (0.7)
Snagging	5.4 (1.2)	5.7 (0.9)
Overall Compatibility	5.9 (0.7)	5.9 (0.6)
Overall Task Performance	5.9 (0.6)	5.9 (0.6)
Comfort		
Fit	6.0 (0.6)	5.9 (0.7)
Weight	6.1 (0.6)	6.3 (0.7)
Bulk	5.6 (0.9)	5.9 (0.7)
Pressure Points	6.4 (0.5)	6.3 (0.6)
Chaffing	6.2 (0.5)	6.2 (0.7)
Protector stiffness	5.7 (0.8)	6.0 (0.6)
Overall Physical Comfort	5.9 (0.7)	6.0 (0.7)
Stability		
Limb Protector Stability	5.6 (0.8)	6.0 (0.6)
Load Carriage Stability	5.8 (0.7)	6.0 (0.6)
Frag Vest Stability	5.9 (0.6)	5.9 (0.7)
Weapon Stabilty	5.6 (0.9)	5.8 (1.1)
Overall Stability	5.8 (0.7)	5.9 (0.8)
Protector Adjustment		
Put On	5.8 (0.8)	5.5 (0.9)
Adjust Fit	5.5 (1.1)	5.6 (1.2)
Take Off	6.0 (0.7)	5.5 (1.1)
Range of Adjustments	5.3 (1.1)	5.8 (0.9)
Adjustment Retention	5.6 (0.8)	5.8 (0.8)
Overall Adjustability	5.7 (0.7)	5.8 (0.8)
Overall Suitability for Field Use	5.6 (0.6)	5.8 (0.7)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for live fire task acceptability scores by question. The results showed one significant difference between the shoulder cap and the brassard. The main effect for range of adjustment was significant (p-value=0.01), where the brassard was found to be more acceptable than the shoulder caps. All other areas showed no trend toward significance in differences between shoulder caps and brassards (see Annex F for significant statistical result details).

Table 14: C7/C8 Live Fire Performance Results

Live Fire Score	Shoulder Caps (n=24) Mean (S.D.)	Brassard (n=24) Mean (S.D.)
Left target (out of 30)	22.4 (6.1)	21.3 (5.5)
Right target (out of 30)	21.0 (5.0)	23.0 (4.1)

An ANOVA for overall range score was conducted to compare the overall results for live fire scores. In terms of live fire accuracy, both the shoulder caps and brassards had similar scores with no significant differences in performance.

4.5.3 Vehicle Compatibility

All participants were asked to access the compatibility of the brassard with a LAV III and a G-wagon. The participants were asked to perform all tasks that are typical within a vehicle on a convoy. Once completed, each participant rated the compatibility of the brassard while performing those tasks. Due to time limit, participants could not evaluate vehicle compatibility for the shoulder caps. The results of the questionnaire are shown below in Table 15. All tasks were rated as being at least "barely acceptable". The only concern was the tight fit while accessing and egressing the crew commanders and gunners hatch. However, it was mentioned that this concern is prominent with the shoulder caps as well. There were no problems completing vehicle tasks within the LAV III and G-wagon while wearing brassards.

Table 15: Vehicle Compatibility Results

Rate the following during vehicle compatibility	Brassard (n=24) Mean (S.D.)
Scanning/Covering Arcs	6.4 (0.8)
Waving off oncoming people/ vehicles	6.5 (0.7)
Scanning High Sides	6.3 (1.0)
Access/ Egress in Air Sentry Hatch	6.0 (0.6)
Access/ Egress in Commander/Gunner Hatch	5.2 (1.1)
Access/ Egress in Drivers Hatch	6.0 (0.6)
Emergency Access/ Egress	5.9 (0.9)
Changing Weapons	6.5 (0.6)
Reloading Weapons	6.5 (0.6)
Normal Driving	6.4 (0.5)
Using Gun Controls	6.0 (0.8)

4.5.4 Obstacle Course

At the end of each obstacle course run, participants completed a task questionnaire to evaluate a wide range of manoeuvrability, ease, comfort, range of motion, compatibility, stability, adjustment, and durability criteria for the test condition just experienced. Using the standard seven-point scale of acceptance, participants rated the acceptability of both the brassard and shoulder cap. The mean values with standard deviation (S.D.) for acceptance are shown below.

The results below indicate that both shoulder caps and brassards rated “barely acceptable”, with the majority of the conditions rated “reasonably acceptable” for the obstacle course – see Table 16 and Table 17.

Table 16: Obstacle Course Compatibility Results

	Shoulder Caps (n=20) Mean (S.D.)	Brassard (n=20) Mean (S.D.)
Manoeuvrability		
Speed of Movement	6.1 (0.5)	6.1 (0.7)
Agility	5.9 (0.6)	6.0 (0.8)
Flexibility	5.9 (0.4)	5.8 (0.9)
Reach	6.0 (0.5)	5.8 (1.0)
Overall Manoeuvrability	6.0 (0.5)	5.9 (0.7)
Ease of Obstacle Traverse		
Running	6.2 (0.5)	6.1 (0.6)
Climbing/Descending Ladders	6.0 (0.6)	5.6 (1.0)
Traversing Ladder	6.1 (0.6)	5.9 (0.9)
Crawling	5.8 (0.7)	5.6 (1.0)
Climbing Low Wall	6.1 (0.5)	6.1 (0.6)
Forward Roll	6.0 (0.5)	5.9 (0.8)
Over/Under	6.0 (0.6)	6.0 (0.6)
Mouse Hole	5.7 (0.7)	5.5 (1.1)
Overall Ease of Traverse	6.1 (0.5)	6.0 (0.6)
Comfort		
Fit	6.1 (0.4)	6.1 (0.6)
Weight	6.3 (0.4)	6.1 (0.6)
Bulk	6.2 (0.5)	5.8 (0.9)
Pressure Points	6.2 (0.5)	6.2 (0.4)
Chaffing	6.2 (0.6)	6.2 (0.6)
Overall Physical Comfort	6.2 (0.4)	6.1 (0.5)
Overall Thermal Comfort	6.2 (0.4)	5.7 (0.9)
Overall Task Performance	6.2 (0.4)	6.1 (0.5)
Range of Motion		
Neck Forward/Back	6.2 (0.6)	6.2 (0.6)
Neck Side to Side	6.1 (0.6)	6.2 (0.6)
Raising Arms up	6.0 (0.6)	5.6 (1.1)
Moving Arms to Front/Back	5.9 (0.6)	5.8 (0.8)
Waist Bending Forward/Back	6.1 (0.6)	6.1 (0.7)
Waist bending Side to Side	6.2 (0.6)	6.1 (0.7)
Twisting	6.1 (0.6)	6.1 (0.6)
Overall Range of Motion	6.0 (0.6)	6.0 (0.8)
Compatibility		
Load Carriage	6.0 (0.6)	6.0 (0.7)
Helmets	6.2 (0.6)	6.2 (0.6)
Fragmentation vest	6.1 (0.6)	6.0 (0.6)
Weapons	6.2 (0.6)	5.9 (0.8)

Table 17: Obstacle Course Compatibility Results (continued)

	Shoulder Caps (n=20) Mean (S.D.)	Brassard (n=20) Mean (S.D.)
Stability		
Limb Protector Stability	6.0 (0.6)	6.0 (0.7)
Load Carriage Stability	6.0 (0.7)	6.1 (0.8)
Adjustment/Durability		
Put On	6.2 (0.4)	6.0 (0.7)
Adjust Fit	6.1 (0.5)	6.2 (0.6)
Take Off	6.2 (0.4)	6.0 (0.8)
Range of Adjustments	6.0 (0.8)	5.9 (0.8)
Adjustment Retention	6.0 (0.6)	5.9 (0.9)
Durability	6.0 (0.6)	6.0 (0.6)
Suitability for Field Use	6.1 (0.6)	6.1 (0.7)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for obstacle course questionnaire acceptability scores. The results showed two significant differences between the shoulder cap and the brassard. The main effects for obstacle course questionnaire were bulk (p-value=0.03) and overall thermal comfort (p-value=0.01) where the brassard was found to be less acceptable than the shoulder caps. All other areas showed no trend toward significance between the shoulder caps and brassards (see Annex F for significant statistical result details).

4.5.5 Battle Task – Vehicle Patrol

Participants completed a battle task which consisted of a vehicle patrol with ambush, followed by a dismounted section attack and completed by a dismounted section FIBUA task. At the end of each vehicle patrol with ambush,,participants completed a task questionnaire to evaluate a wide range of manoeuvrability, vehicle compatibility, overall compatibility, mounted combat compatibility, comfort, and stability criteria for the test condition just experienced.

Using the standard seven-point scale of acceptance, participants rated the acceptance of both shoulder cap and Brassard shoulder fragmentation protection. The mean values with standard deviations (SD) for acceptance are presented below.

The results indicate that both shoulder caps and brassards rated above ‘barely acceptable’ and the majority of the conditions were rated “reasonably acceptable” for the mounted section crewman task mean values – See Table 18.

Table 18: Battle Task – Vehicle Patrol with Ambush

	Shoulder Caps (n=20) Mean (S.D.)	Brassard (n=20) Mean (S.D.)
Manoeuvrability		
Speed of Movement	6.3 (0.6)	6.2 (0.6)
Agility	6.2 (0.6)	6.1 (0.8)
Flexibility	6.0 (0.7)	6.2 (0.7)
Overall Manoeuvrability	6.2 (0.5)	6.1 (0.7)
Vehicle Compatibility		
Normal Access	6.2 (0.6)	6.0 (0.8)
Normal Egress	6.1 (0.6)	6.1 (0.7)
Emergency Access	6.1 (0.7)	6.0 (0.9)
Emergency Egress	6.0 (0.7)	5.9 (0.9)
Ease of Driving/Operating Weapons/Turret	6.2 (0.6)	6.1 (0.7)
Ability to Perform all Duties	6.1 (0.6)	6.2 (0.6)
Overall General Vehicle Compatibility	6.1 (0.6)	6.1 (0.7)
Compatibility		
Helmet	6.4 (0.5)	6.1 (0.6)
Frag vest	6.2 (0.6)	6.0 (0.6)
Gloves	6.3 (0.7)	6.1 (0.6)
Weapons	6.3 (0.4)	6.2 (0.5)
Snagging	5.9 (0.8)	5.7 (1.0)
Overall Compatibility	6.2 (0.4)	6.1 (0.6)
Overall Task Performance	6.2 (0.4)	6.2 (0.6)
Mounted Combat		
Scanning/ covering arcs	6.3 (0.5)	6.2 (0.7)
Firing personal weapons	6.4 (0.5)	6.2 (0.6)
Changing mags, ammo boxes for C6/ ammo for C9	6.3 (0.6)	6.3 (0.6)
Firing M72s and 40 mms/, throwing grenades	6.1 (0.6)	6.1 (0.7)
Engagement of targets using pintle mount:	6.2 (0.6)	6.2 (0.7)
Engaging targets with vehicle weapons	6.3 (0.5)	6.2 (0.8)
Combat dismount	6.4 (0.5)	6.1 (0.8)
Comfort		
Fit	6.2 (0.4)	5.9 (0.7)
Weight	6.3 (0.4)	6.1 (0.6)
Bulk	6.1 (0.6)	5.8 (0.8)
Pressure points	6.2 (0.5)	6.1 (0.6)
Chaffing	6.2 (0.6)	6.1 (0.5)
Overall Physical Comfort	6.2 (0.4)	6.0 (0.7)
Stability		
Fragmentation Vest Stability	6.1 (0.7)	6.1 (0.4)
Upper Limb Protector Stability	6.0 (0.7)	6.2 (0.5)
Overall Stability	6.2 (0.5)	6.1 (0.5)
Overall Suitability for Field Use	6.0 (0.6)	6.3 (0.4)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for mounted section crewman tasks acceptability scores. The results showed no significant differences between the shoulder cap and the brassard. No preference was found for either the shoulder caps or brassards for mounted section crewman tasks.

4.5.6 Battle Task - Dismounted Section Fire and Movement Task

At the end of each dismounted section fire and movement task, participants completed a task questionnaire to evaluate a wide range of manoeuvrability, ease of use, overall compatibility, comfort, and stability criteria for the test condition just experienced. Using the standard seven-point scale of acceptance, participants rated the acceptance of both shoulder cap and brassard. The mean values with standard deviations (SD) for acceptance are presented below.

The results below indicate that both shoulder caps and brassards rated above 'barely acceptable' and the majority of the conditions were rated "reasonably acceptable" for the dismounted section fire and movement task mean values – see Table 19.

Table 19: Dismounted Section Fire and Movement Task Compatibility Results

	Shoulder Caps (n=19) Mean (S.D.)	Brassard (n=19) Mean (S.D.)
Manoeuvrability		
Speed of Movement	6.3 (0.5)	6.3 (0.5)
Agility	6.2 (0.4)	6.2 (0.5)
Flexibility	6.2 (0.5)	6.2 (0.5)
Overall Manoeuvrability	6.3 (0.5)	6.2 (0.5)
Ease of Fire & Movement		
Running	6.2 (0.5)	6.2 (0.5)
Dropping to prone position	6.3 (0.6)	6.2 (0.6)
Crouching	6.2 (0.5)	6.3 (0.5)
Crawling	6.3 (0.6)	6.2 (0.5)
Adopting prone fire position	6.3 (0.7)	6.3 (0.6)
Adopting kneeling fire position	6.4 (0.5)	6.4 (0.5)
Adopting standing fire position	6.2 (0.6)	6.3 (0.7)
Sighting	6.2 (0.5)	6.2 (0.5)
Firing	6.4 (0.5)	6.2 (0.5)
Loading/Unloading	6.3 (0.5)	6.2 (0.5)
Accessing mags/grenades	6.3 (0.5)	6.3 (0.5)
Throwing grenades	6.1 (0.7)	5.7 (0.9)
Standing up	6.2 (0.5)	6.1 (0.7)
Overall F&MT Performance	6.3 (0.5)	6.0 (0.6)
Compatibility		
Load Carriage	6.2 (0.8)	6.1 (0.6)
Helmet	6.3 (0.6)	6.3 (0.5)
Frag vest	6.4 (0.5)	6.1 (0.5)
Gloves	6.3 (0.6)	6.3 (0.6)
Weapons	6.4 (0.5)	6.3 (0.5)
Snagging	5.9 (0.7)	5.9 (0.6)
Overall Compatibility	6.3 (0.5)	6.2 (0.4)
Limb Protector Comfort		
Fit	6.3 (0.5)	5.9 (0.6)
Weight	6.4 (0.5)	6.1 (0.5)
Bulk	6.1 (0.7)	5.9 (0.6)
Pressure points	6.3 (0.5)	5.9 (0.6)
Chaffing	6.4 (0.5)	5.8 (0.6)
Stiffness	6.2 (0.5)	6.1 (0.5)
Overall Physical Comfort	6.2 (0.5)	6.0 (0.6)
Overall Thermal Comfort	6.2 (0.4)	5.6 (0.7)
Stability		
Fragmentation Vest Stability	6.2 (0.4)	6.0 (0.6)
Upper Limb Protector Stability	6.2 (0.6)	6.1 (0.5)
Overall Stability	6.2 (0.6)	6.1 (0.5)
Overall Suitability for Field Use	6.1 (0.6)	6.1 (0.5)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for dismounted section fire and movement task acceptability scores. The results showed two significant differences between the shoulder cap and brassard. The significant main effects for dismounted section fire and move tasks were overall thermal comfort (p-value=0.00) and chaffing (p-value=0.02) where brassard was found to be less acceptable than the shoulder caps. All other areas showed no trend toward significance between the shoulder caps and brassards (see Annex F for statistical result details). There were slight problems with the brassard with regards to chaffing and thermal comfort during the fire and movement task.

4.5.7 Battle Task - Dismounted Section FIBUA Task

At the end of each dismounted section FIBUA task, participants completed a task questionnaire to evaluate a wide range of manoeuvrability, ease of movement, stability, overall compatibility, and comfort criteria for the test condition just experienced. Using the standard seven-point scale of acceptance, participants rated the acceptance of both shoulder cap and brassard. The mean values with standard deviations (SD) for acceptance are presented below.

The results below indicate that both shoulder caps and brassards rated above 'barely acceptable'or 5 with the majority of the conditions being rated "reasonably acceptable" or 6 for the dismounted section FIBUA task mean values – see Table 20.

Table 20: Dismounted Section FIBUA Task Compatibility Results

	Shoulder Caps (n=21) Mean (S.D.)	Brassard (n=21) Mean (S.D.)
Manoeuvrability		
Speed of Movement	6.2 (0.6)	6.2 (0.5)
Agility	6.1 (0.6)	6.2 (0.5)
Flexibility	6.1 (0.8)	6.1 (0.6)
Overall Manoeuvrability	6.2 (0.6)	6.2 (0.4)
Ease of FIBUA Movement		
Building entry	6.1 (0.8)	6.2 (0.5)
Inside door entry	6.2 (0.7)	6.3 (0.6)
Climbing/descending ladders	6.1 (0.8)	6.1 (0.6)
Climbing/descending stairs	6.2 (0.8)	6.4 (0.6)
Passage up/down through floor/ceiling breach holes	6.0 (0.9)	6.0 (0.6)
Passage through wall breach holes	6.0 (0.9)	6.0 (0.6)
Room clearance	6.4 (0.5)	6.3 (0.4)
Adopting FIBUA fire positions	6.2 (0.7)	6.2 (0.4)
Overall FIBUA Task Performance	6.1 (0.7)	6.2 (0.4)
Stability		
Fragmentation Vest Stability	6.1 (0.6)	6.3 (0.4)
Upper Limb Protector Stability	5.9 (0.9)	6.2 (0.4)
Overall Stability	6.1 (0.7)	6.2 (0.4)
Compatibility		
Load Carriage	6.1 (0.7)	6.2 (0.4)
Helmet	6.2 (0.7)	6.0 (0.5)
Frag vest	6.4 (0.6)	6.2 (0.5)
Gloves	6.2 (0.7)	6.2 (0.6)
Weapons	6.2 (0.7)	6.3 (0.4)
Snagging	5.8 (0.9)	6.1 (0.6)
Overall Compatibility	6.2 (0.7)	6.2 (0.5)
Limb Protector Comfort		
Fit	6.0 (0.8)	6.0 (0.6)
Weight	6.2 (0.6)	6.2 (0.4)
Bulk	6.3 (0.5)	6.0 (0.6)
Pressure points	6.2 (0.7)	6.1 (0.5)
Chaffing	6.2 (0.8)	5.9 (0.5)
Stiffness	6.0 (0.7)	6.2 (0.5)
Overall Physical Comfort	6.2 (0.7)	6.2 (0.4)
Overall Thermal Comfort	6.1 (0.6)	5.8 (0.9)
Overall Suitability for Field Use	6.2 (0.6)	6.2 (0.4)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for dismounted section FIBUA task by question. The results showed one significant difference between the shoulder cap and the brassard. The significant main effect for the dismounted section FIBUA task questionnaire scores was chaffing (p-value=0.01) where the brassard was found to be less acceptable than the shoulder caps. All other areas showed no trend toward significance between the shoulder caps and brassards (see Annex F for significant statistical result details).

4.6 Feature Functionality and Durability

Participants completed a feature functionality and durability questionnaire to evaluate a wide range of features for both durability and functionality at the end of the each complete run for a condition. Using acceptability ratings on a scale of 1 to 7, participants rated the shoulder cap and brassard design features for functionality and durability acceptance. The mean values with standard deviation (S.D.) for acceptance are presented in Table 21 and Table 22. Shading was used to indicate low acceptable (less than 4) ratings.

Table 21: Shoulder Cap Feature Durability and Functionality Results

	Functionality (n=22)	Durability (n=22)
FEATURES	Mean (S.D.)	Mean (S.D.)
Top Velcro Attachment	5.4 (1.0)	5.6 (0.8)
Back Snap Attachment	4.6 (1.3)	4.9 (1.0)
Front Snap Attachment	5.2 (1.1)	5.2 (1.1)
Shoulder Area Coverage	4.8 (1.1)	5.6 (1.1)
Velcro Pouch (on back)	5.2 (1.1)	5.7 (0.8)

Overall participants rated 3 features "barely acceptable" for functionality on the shoulder cap: top Velcro attachment, front snap attachment, and Velcro pouch (on back). Overall participants rated 2 features "borderline" for functionality on the shoulder cap: back snap attachment and shoulder area coverage. Overall participants rated 4 features "barely acceptable" for durability on the shoulder cap: top Velcro attachment, front snap attachment, shoulder area coverage, and Velcro pouch (on back). Overall participants rated 1 feature "borderline" for durability on the shoulder cap: back snap attachment.

Table 22: Brassard Feature Durability and Functionality Results

	Functionality	Durability
FEATURES	Mean (S.D.)	Mean (S.D.)
Top Attachment (n=23)	5.9 (0.8)	5.8 (0.8)
Back Attachment (n=23)	5.3 (0.9)	5.5 (0.9)
Straps (n=22)	5.8 (1.0)	5.6 (0.8)
Pocket Zippers (n=21)	5.5 (1.4)	5.7 (1.1)
Back Upper Arm Area Coverage (n=23)	6.2 (0.6)	6.3 (0.5)
Pocket Velcro Attachment Area (n=23)	5.7 (1.0)	5.9 (5.3)
Bicep Strap (n=22)	5.1 (1.1)	5.3 (1.1)
Bottom Velcro Attachment Area (n=18)	5.9 (0.7)	5.9 (0.8)
Front Upper Arm Area Coverage (n=21/22)	6.2 (0.5)	6.3 (0.6)
Pocket (n=22)	5.3 (1.5)	5.9 (1.1)
Front Attachment (n=23)	5.7 (0.9)	5.7 (0.8)
Shoulder Area Coverage (n=23)	6.2 (0.5)	6.2 (0.5)

Overall participants rated 3 features "reasonably acceptable" for functionality on the brassard: back upper arm area coverage, front upper arm area coverage, and shoulder area coverage. Overall participants rated 9 features "barely acceptable" for functionality on the brassard: top attachment, back attachment, straps, pocket zippers, pocket Velcro attachment area, bicep strap, bottom Velcro

attachment area, pocket, and front attachment. Overall participants rated 3 features "reasonably acceptable" for durability on the brassard: back upper arm area coverage, front upper arm area coverage, and shoulder area coverage. Overall participants rated 9 features "barely acceptable" for durability on the brassard: top attachment, back attachment, straps, pocket zippers, pocket Velcro attachment area, bicep strap, bottom Velcro attachment area, pocket, and front attachment

In general, the brassard was more acceptable for both functionality and durability of features than the current shoulder cap. Participants had issues with the functionality of the back snap attachment and shoulder area coverage of the current shoulder cap design.

4.7 Physical Discomfort

At the end of full day of use with one of the shoulder fragmentation protection designs, participants completed a physical comfort questionnaire regarding the physical discomfort level and location of discomfort with each design. Using a standard five-point rating scale of discomfort, participants rated the acceptability of physical comfort by location – see Figure 25. The results below indicate the location and percentage of participants rating the systems as generally comfortable, i.e. less than or equal to 2 ("Slight Discomfort") - see Table 23.

Table 23: Physical Discomfort Results

Area	Physical Discomfort Rating 2 or less	
	Shoulder Cap (n=22)	Brassard (n=23)
1. Chest	100.0 %	100.0%
2. Shoulder	100.0 %	100.0 %
3. Arm pit	100.0 %	100.0 %
4. Stomach	100.0 %	100.0 %
5. Back	100.0 %	100.0 %
6. Lower back	95.5%	95.7 %
7. Neck / upper shoulders	90.9 %	95.7 %
Overall (one or more location rated 2 or less)	90.9 %	95.7 %

Non parametric (Chi square) tests were conducted to compare each region for frequency of reported discomfort. In terms of physical discomfort, both the shoulder caps and brassards had similar results with no significant differences between conditions. For the physical discomfort questionnaire, 100% of the participants found both shoulder designs acceptable for shoulder comfort.

4.8 Thermal Discomfort

At the end of a full day of use with either the brassard or shoulder caps, participants completed a thermal discomfort questionnaire regarding the thermal discomfort levels and location of discomfort – see Figure 26. Using a standard five-point rating scale of thermal discomfort, participants rated the acceptability of thermal discomfort. The results below indicate the location and percentage of participants rating the systems as thermally acceptable, i.e. less than or equal to 2 ("Slight Warm") – see Table 24.

Table 24: Thermal Comfort Questionnaire Ratings Results

Area	Thermal Discomfort Rating 2 or less	
	Shoulder Cap (n=22)	Brassard (n=23)
1. Chest	81.8%	70%
2. Shoulder	77.3%	70 %
3. Arm pit	68.2%	70 %
4. Stomach	90.9%	70 %
5. Back	63.4%	73.9%
6. Lower back	77.3%	82.6 %
Overall (one or more location rated 2 or less)	50.0 %	30.4 %

Non parametric (Chi-square) tests were conducted to compare each region. In terms of thermal discomfort, both the shoulder caps and brassards had similar results with no significant differences (no main effects) between conditions. On the thermal comfort questionnaire, 70 % of the participants found both designs acceptable for thermal comfort at the shoulder. The extra coverage provided by the brassard did not appear to impose a significant thermal burden in the shoulder area.

4.9 Daily Exit Questionnaire

At the end of the each day participants completed a daily exit questionnaire regarding ease of operation, compatibility, comfort, stability, protector adjustment, and overall field use for either the brassard or shoulder caps. Again the standard seven-point scale of acceptance was used to rate each question. The mean values with standard deviation (S.D.) for acceptance are shown below.

The results below indicate that both shoulder caps and brassards rated “borderline” and the majority of the conditions were rated “reasonably acceptable” for the daily exit questionnaire mean values – see Table 21.

Table 25: Daily Exit Questionnaire Results

Criteria	Shoulder Caps (n=22) Mean (S.D.)	Brassard (n=22) Mean (S.D.)
Initial Fit	5.9 (0.6)	6.0 (0.6)
Fit Retention	5.9 (0.8)	5.5 (1.1)
Donning/Doffing	5.8 (0.8)	5.7 (0.9)
Overall Ease of Adjustment	5.9 (0.7)	5.8 (0.8)
• Ease of Adjustment in Vehicle	5.7 (0.9)	5.8 (0.7)
• Ease of Adjustment in Dismounted	5.9 (0.8)	6.1 (0.5)
• Adjustment Retention	5.5 (1.0)	5.5 (0.9)
Snagging in the vehicle	5.2 (0.8)	5.2 (1.3)
Snagging while dismounted	5.6 (0.7)	5.8 (0.8)
Shoulder Coverage	4.8 (1.3)	6.4 (0.6)
Upper Arm Coverage	4.3 (1.6)	6.3 (0.6)
Shoulder Range of Motion	5.5 (1.6)	6.0 (0.8)
Ease of Use as a System	5.8 (0.7)	6.1 (0.6)
Features Acceptance (pockets, etc.)	5.1 (1.4)	5.6 (1.2)
Compatibility with rest of PPE	5.7 (0.9)	6.0 (0.5)
Compatibility with weapons	5.7 (0.9)	6.1 (0.5)
Compatibility while driving	5.8 (0.7)	6.2 (0.6)
Compatibility with clothing	6.0 (0.7)	6.1 (0.5)
Overall Ease of Movements:	5.8 (0.8)	6.1 (0.7)
Entering/Exiting Hatches	5.4 (1.0)	5.2 (1.3)
Entering/Exiting Vehicle	5.6 (0.7)	5.7 (0.8)
Ability to Manoeuvre Through Buildings	6.0 (0.8)	6.2 (0.4)
Ability to Engage Targets While Stationary	6.1 (0.6)	6.3 (0.5)
Ability to Engage Targets While Moving	6.0 (0.6)	6.2 (0.6)
Thermal Comfort	5.5 (1.0)	5.2 (1.3)
Physical Comfort	5.8 (0.6)	6.0 (0.7)
Pressure Points	6.0 (0.7)	6.2 (0.7)
Skin Irritation	6.0 (0.7)	6.1 (0.5)
Hot Spots	5.5 (1.1)	5.5 (1.1)
Weight	6.1 (0.7)	6.3 (0.5)
Shoulder Discomfort	5.9 (0.7)	6.3 (0.5)
Ability to Perform Loader tasks	6.0 (0.7)	6.2 (0.7)
Ability to Perform Gunners tasks	5.9 (0.8)	5.8 (0.9)
Ability to Perform Driving Tasks	5.9 (0.6)	6.0 (0.7)
Ability to Perform Air Sentry Tasks	6.1 (0.4)	6.1 (0.7)
Ability to Perform Observation (other then Air Sentry) Tasks	6.0 (0.7)	6.1 (0.6)
Ability to Perform Mounted Infantry Tasks	6.0 (0.7)	6.0 (0.6)
Ability to Perform Dismounted Infantry Tasks	6.1 (0.7)	6.2 (0.4)
Suitability for FIBUA House Clearing Tasks	6.0 (0.8)	6.3 (0.5)
Ability to Perform Fire and Movement Tasks	6.0 (0.8)	6.1 (0.5)
Ability to Perform Vehicle Patrol Tasks	6.0 (0.6)	6.2 (0.4)
Suitability for Climbing	5.4 (1.0)	5.8 (0.9)
Suitability for Crawling	5.4 (0.9)	5.9 (0.9)
Suitability for Throwing	5.5 (0.6)	5.6 (0.9)
Ability to Move in Tight Quarters (such as a breach hole)	5.2 (1.0)	5.8 (0.6)
Overall system rating	5.8 (0.5)	6.0 (0.6)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for daily exit questionnaire acceptability scores. The results showed seven

significant differences between the shoulder cap and the brassard. The significant effects for daily questionnaire scores were shoulder coverage (p-value=0.00), upper arm coverage (p-value=0.00), feature acceptability (p-value=0.05), compatibility with driving (p-value=0.03), suitability for climbing (p-value=0.03), suitability for crawling (p-value=0.01), and ability to move in tight quarters (p-value=0.03) where the brassard was found to be more acceptable than the shoulder caps. All other areas showed no trend toward significance between the shoulder caps and brassards (see Annex F for significant statistical result details).

4.10 Final Exit Questionnaire

At the end of the trial, each participant completed a final exit questionnaire that directly compared shoulder caps to the brassard in terms of fit, comfort, ease of use, coverage, bulk, and compatibility. Questions were rated using the standard seven-point scale of acceptance, with completely unacceptable at 1, borderline at 4, and completely acceptable at 7. The mean values with standard deviation (S.D.) for acceptance are shown below, with shading used to indicate low acceptable (less than 4) ratings.

The results below indicate that for the majority of criteria, shoulder caps and brassards were rated as “reasonably acceptable” for the final exit questionnaire mean values – see Table 26. The majority of features were not found to be different between the shoulder caps and brassards.

Table 26: Final Exit Questionnaire Results

Criteria	Shoulder Caps (n=21) Mean (S.D.)	Brassard (n=21) Mean (S.D.)
Fit	5.7 (0.6)	6.1 (0.6)
Fit adjustment(s)	5.3 (0.8)	5.8 (0.7)
Adjustment retention	5.6 (0.6)	5.5 (0.9)
Stability	5.4 (0.9)	6.0 (0.6)
Security / Retention	5.2 (0.8)	5.6 (0.7)
Physical comfort:	6.0 (0.6)	6.0 (0.7)
Thermal comfort	6.1 (0.7)	5.5 (0.9)
Ease of use – attaching and removing	6.0 (0.8)	5.6 (0.7)
Snagging	5.2 (1.1)	5.4 (0.8)
Flexibility	5.5 (0.8)	5.8 (0.4)
Bulk	5.7 (0.9)	5.9 (0.6)
Ease of movement (with)	6.0 (0.7)	6.1 (0.6)
Weight	6.2 (0.6)	6.3 (0.6)
Coverage	3.9 (1.2)	6.0 (0.6)
Compatibility with clothing	6.0 (0.8)	6.1(0.6)
Compatibility with equipment	5.9 (0.8)	6.0 (0.5)
Compatibility with weapons	6.0 (0.9)	5.9 (0.7)
Compatibility with vehicles	5.7 (0.8)	6.0 (0.7)
Compatibility with dismounted combat tasks	6.2 (0.5)	6.2 (0.6)
Compatibility with mounted combat tasks	5.8 (0.7)	6.0 (0.7)
Compatibility with general support tasks	6.1 (0.6)	6.2 (0.6)
Feature set	5.0 (1.0)	5.8 (1.0)
Maintainability	6.1 (0.6)	6.0 (0.6)
Durability	5.9 (0.8)	5.8 (0.5)
Suitability for operations	5.4 (1.1)	6.1 (0.4)
Overall systems rating	5.2 (0.8)	6.0 (0.5)

Friedman ANOVA and Kendall Coefficient of Concordance tests were conducted to compare the overall results for final exit questionnaire acceptability scores. The results showed nine significant differences between the shoulder cap and the brassard, on seven metrics the brassard was found to be significantly more acceptable than the shoulder caps and on two metrics the shoulder cap was rated significantly more acceptable than the brassard. The seven measures where the brassard was found to be more acceptable than the shoulder caps were fit (p-value=0.02), fit adjustability (p-value=0.01), stability (p-value=0.01), coverage (p-value=0.00), feature set (p-value=0.00), stability for operations (p-value=0.00), and overall (p-value=0.00). The two measures where the brassard was found to be less acceptable than the shoulder caps were thermal comfort (p-value=0.00) and ease of use (p-value=0.03). All other areas showed no trend toward significance between the shoulder caps and brassards (see Annex F for significant statistical result details).

4.11 Focus Group Discussion

All participants took part in a focus group discussion regarding the brassard design at the end of the trial. The exit focus group occurred on the last day of the trial (May 31, 2007). The discussion took place after all participants had exposure to the brassard design. A summary of major comments made by the participants and percentage of participants agreeing to particular point during the focus group discussion is presented below – see Table 27.

Table 27: Focus Group Topics and Results

Topic	Percentage
Compatibility	(n=21)
• Issues with bulk	0%
• Issues with ease of shoulder movement	0%
• Issues with equipment / weapons	0%
• Issues during FIBUA	0%
• Thought brassard catches on stuff less than current shoulder cap design	57.1%
Fit	
• Wrong brassard size issued	0%
• Issues with girth too big	9.5%
• Issues with strap too long	23.8%
• Issues with strap too short	0%
• Issue with top of brassard	0%
• Issues with the buckle design became loose (11 of 21 used buckle design)	81.8%
• Issues with elbow clashing	4.7%
• Issues with protection compromised do to loose fitting	23.8%
• The brassard being too tight would not be useful	19%
Stability and Comfort	
• Issues with unstable	0%
• Issues with physical discomfort	0%
• Issues with thermal discomfort	38%
• Issues with ease of use	0%
Attachment Points Design	
• Issues with back snap security	52%
• Preference for one way “pull the dot” snap	100%
Bicep Strap design	
• Issues with buckles touching	61.9%
• Move buckle to padded area	95.2%
• Thicker Velcro	47.6%
• Preference for elastic bicep strap	100%
• Issues with extra straps	14%
Pen Holder Design	
• No problem with pen pocket	14%
• Issues with usability of pen pocket	47.6%
• Move pen pocket to outside of brassard	90.4%
• Wanted bottom access to pen holder	0%
• Need for pen holder cover	100%
• Pen holder/ glow stick holder design, needs to be relocated.	100%
• Angled with pocket	61.9%
• Straight up/down orientation	14.3%
• Single pen holder	28.6%
• Double pen holder	38%
• Glow stick more important than pen holder	90.4%
Pocket Design	
• Bigger pocket preference over the smaller pocket design	100%
• Affinity for top-down zipper	100%

All participants considered the brassard a better design than the current shoulder cap. Since participants considered the fragmentation protection of the current shoulder cap of limited value, and the brassard improves shoulder protection with minimal task performance detriment, the

brassard was considered a good alternative. Most participants accepted the requirement of extra shoulder protection in-order to minimize injury from fragmentation.

Most participants preferred the brassard with the bigger pocket and top-down zipper design, and the bicep buckle with elastic strap adjustment attachment. The main issues with the current design were poor back shoulder snap attachment, extra bicep strap length, location and retention of buckle, poor rear shoulder snap attachment, and access to current pen holder. A positive step forward on the brassard design is for the bicep attachment to be a buckle with the buckle moved to padded area, an elastic bicep strap, and the ability for extra strap material to be held out of the way with Velcro. Furthermore, changing the current snap design to 'pull the dot' snaps was recommended by the participants. Finally a pen pocket/glow stick holder should be moved in orientation to match the utility pocket and lowered in order to improve access to the pocket.

4.12 Overall Results

The overall performance of both shoulder fragmentation protection options was good. A summary of the different tasks is provided in Table 28 below.

Table 28: Summary of Results

✓ = generally acceptable (mean value equal to "borderline" or better)

Questionnaires	Overall Shoulder Cap	Overall Brassard	Significant different between the two conditions B= Brassard S = Shoulder caps
Fit Assessment	✓	✓	None
Individual weapons and equipment tasks	✓	✓	None
Live fire	✓	✓	B > S for range of adjustment
Mounted crewman tasks	✓	✓	None
Dismounted section fire and movement tasks	✓	✓	S > B for overall thermal comfort & chaffing
Dismounted section FIBUA tasks	✓	✓	None
Obstacle course	✓	✓	S > B for both bulk & thermal
Daily Exit	✓	✓	B > S for shoulder coverage, upper arm coverage, feature, compatibility with driving, suitability for climbing, suitability for crawling, & ability to move in tight quarters
Thermal Comfort	✓	✓	None
Physical Comfort	✓	✓	None
Feature Functionality	✓	✓	-
Feature Durability	✓	✓	-
Final exit	✓	✓	B > S for fit, fit adjustability, stability, coverage, feature set, suitability for operations, & overall S > B for thermal comfort and ease of use

As the above table shows, both designs were acceptable for the wide range of tasks carried out during this trial.

5 Discussion

A field trial was undertaken to evaluate user acceptance and performance of a new shoulder and upper arm fragmentation protection device. The 4 day trial was completed at CFB Petawawa with twenty-five regular force infantry soldiers who undertook a battery of operational and human factors tests while wearing the brassard and the current in-service shoulder caps.

Human factors tests included assessment of fit, anthropometry, range of motion, area of coverage, compatibility with clothing/equipment/vehicles, performance of FIBUA tasks, battle tasks, obstacle course, range firing, grenade throwing, thermal load, and physical comfort. Data collection included questionnaires, focus groups, performance measures, and HF observer assessments.

The participants in this trial represented a large portion of the CF population. The male participants represented almost the entire CF population with respect to the anthropometric measurements taken. Since the goal of the brassard is to add protection to the upper arm area, the measure that should be used in sizing brassards is the shoulder-elbow length. According to this measurement, the males represented the 5^{th} to the 99^{th} percentiles of the male CF population. The regular sized brassard is able to accommodate the about half of that population while the large brassard is able to accommodate the other half. It is safe to say that very few or no male soldiers would require the small brassard. The females that participated in this experiment represented the 10^{th} to the 55^{th} percentiles of the female CF population. The three females that wore the small brassard were 10^{th} and 55^{th} percentile females.

The overall performance of the brassard was very good. A large number of participants mentioned that they did not even notice a difference between the brassard and the current in-service shoulder caps. Soldiers also noted that with the added protection value of the brassard, it is a superior choice to the current shoulder caps.

In terms of shoulder range of motion, there were not any significant differences between the brassard and shoulder caps. Soldiers were still able to move their shoulder as freely as they were able to with the shoulder caps. Since each soldier was properly fitted with the correct size of brassard, no conclusions on the effects on range of motion for those soldiers whom the brassards are not properly fitted can be drawn. Therefore it is important that each soldier be properly fitted for the brassards.

Compared to the current in-service shoulder caps, the brassard performed favourably in all the compatibility assessments. There were no problems with the brassard in operating any weapons or with any of the current clothing and equipment. Soldiers did not notice any difference between the brassard and shoulder caps during their mounted crewman task, obstacle course, and their FIBUA task. There were slight advantages of the shoulder caps over the brassard with regards to chaffing and thermal comfort during the fire and movement task. Even though there were significant differences between the shoulder caps and brassard with respect to chaffing and thermal comfort, the brassard was still rated “barely acceptable” or higher. Therefore, the brassard does not pose any major problems during a fire and movement task. There were also some issues with the brassard compatibility with the LAV III. Some participants mentioned that getting into and out of the Gunners and Crew Commanders station was tight. However, this issue is common even with shoulder caps. The size of the Gunners and Crew Commanders hatch is significantly smaller than the Drivers and family hatch. In fact, participants preferred the brassard to the shoulder caps for getting into and out of the Gunners and Crew Commanders hatch because it fit closer to the arm and it moved more fluidly with the arm than the shoulder caps.

At the end of each day, the participants completed a daily exit questionnaire to reflect a single day's use of either the brassard or shoulder caps. There were no significant differences between the brassards and shoulder caps except for coverage of the upper arm and shoulder where the brassard was favoured over the shoulder cap, due to the brassard's increased coverage design.

There were also no significant physical discomfort issues with the shoulder caps or brassards. There were some issues with thermal comfort when wearing the brassard around the back and stomach areas. Since, the brassard does not cover these area it is hard to understand how the brassard was the cause of this thermal discomfort. It could be that the counterbalancing of conditions did not fully eliminate the effect of the temperature varying over the multiple days of the trial.

At the conclusion of the trial, each participant completed an exit questionnaire that evaluated the brassard and shoulder caps head-to-head. Although generally differences were not statistically significant, the brassard typically outperformed the shoulder caps except in areas such as thermal comfort and ease of attachment and removing. This is understandable considering that the brassard covers the entire upper arm and has more attachments than the shoulder caps.

At the conclusion of the trial, a focus group was held to discuss the features of the brassard and recommended changes to the design. The majority of the participants agreed on a number of changes to the brassard. The first change recommended is the incorporation of a pen holder/glow stick holder moved to the outside of the brassard with a cover that can be attached with Velcro so that it does not get in the way. There was stronger preference for a double pen holder over a single pen holder while the preference for a glow stick holder over a pen holder was almost unanimous. There was also a unanimous agreement that the pocket on the outside of the brassard should be made bigger with a top-down zipper instead of the angled zipper. The participants also had an issue with the bicep attachment.

There were also concerns regarding the attachment methods. The snaps at the front and back of the brassard had a tendency to be pulled off easily and were difficult when trying to re-attach. A solution would be to have 'pull the dot' snaps instead. These snaps can only be broken when properly aligned. Therefore, there is a greater likelihood that these snaps will not come undone during normal soldier duties. The attachment on the large brassard appeared to be too long and the buckles tended to touch each other. This did not allow a proper tight fit of the brassard around the bicep. However, the Velcro attachment on the regular brassard allowed the participants to have a tight secure fit of the brassard around the bicep. Therefore, an attachment similar to the regular brassard is desired, but the Velcro may be substituted for a buckle attachment on the outside of the brassard.

No study is without limitations. One limitation of this field trial is the small sample size of females. While it was concluded that the vast majority of males can wear either the large or regular sized brassard, it would have been beneficial to have a range of females (typically smaller in proportion to males) to see what percentages would wear which sizes of brassards. Another limitation of the trial is the short time frame that the participants had to evaluate the brassard. It is hard to encompass all of the tasks that soldiers perform in three days, so it is impossible to conclude that the brassard is superior to the shoulder caps in all possible areas. However, the participants did go through typical soldier drills that are meant to represent most soldier tasks and the brassard performed on par or better than the shoulder caps. Longer use of brassard would also provide more valuable feedback about durability, and physical and thermal comfort. The trial was also completed in warm dry conditions which will not always be the case in theatre. Therefore, the durability and comfort could not be assessed in wet and cold conditions. The final limitation to this field trial was the lack of operational experience of the participants. Very few participants had operational

experience so their insight into certain features and usability of the brassard could be considered limited.

Despite the limitations in this study, the brassard performed very well and in many cases superior to the shoulder caps. Therefore, the brassard is a valuable alternative to the shoulder caps and the decision to use brassards in place of shoulder caps is supported by the results of this study.

This page intentionally left blank.

6 Recommendations

Recommendations on the way ahead for the brassard design are detailed below as well as specific recommendations on brassard design. The results of this trial suggest that a brassard is the way forward for shoulder fragmentation protection as it has similar task performance and acceptability as the current shoulder cap while providing much greater area of coverage.

Participants suggested several design improvement to the brassard design. Design changes recommended by the participants in this study included:

- Use buckle option on bicep strap and moved buckle to padded area.
- Use elastic bicep strap and give the soldier the ability to tuck extra strap material away and secure with Velcro.
- Change snap design to pull away dot snap in order to minimize accidental release of snap.
- Pen pocket/glow stick holder to be moved closer to front shoulder area, put in the same orientation as the utility pocket, and lowered in order to improve access and usability of pocket.

This page intentionally left blank.

7 References

1. Armed Forces Institute of Pathology (2005). Marine Lethal Torso Injuries: Preliminary Findings. Marince Corps System Command, MARCORSYSCOM, Quantico, VA. Retrieved April 17, 2007, from http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA442169
2. Chamberland, A., Carrier, R., Forest, F., and Hachez, G. (1997). Anthropometric Survey of the Land Forces, DCIEM Report No. 98-CR-15.

This page intentionally left blank.

Annex A: Trial Feature Questionnaires

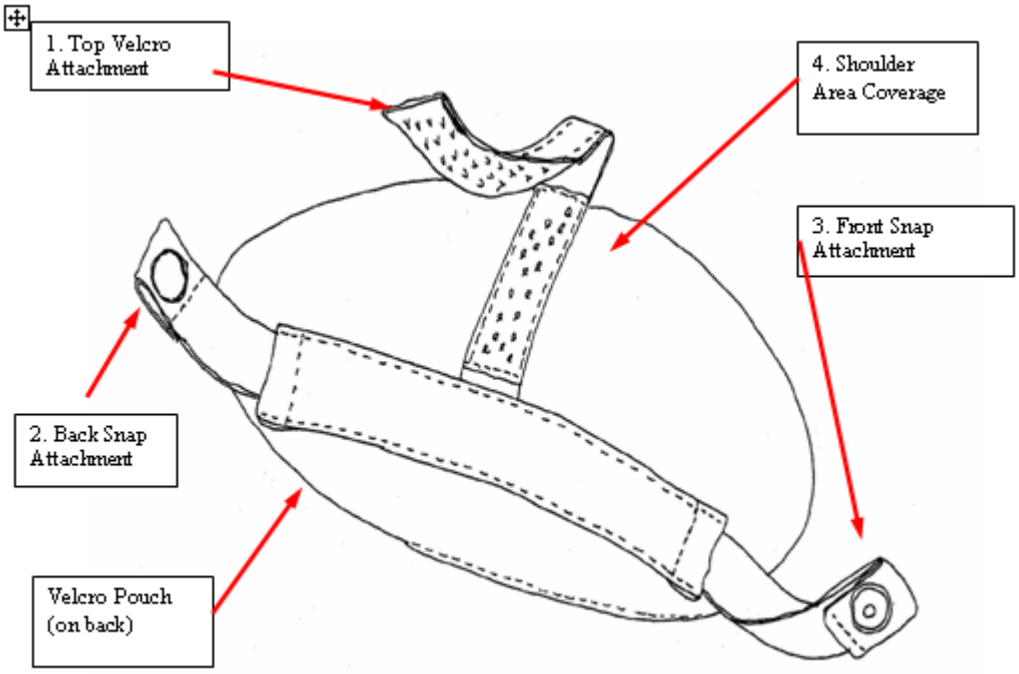
Annex A:

Trial Feature Questionnaires

This page intentionally left blank.

Annex A:

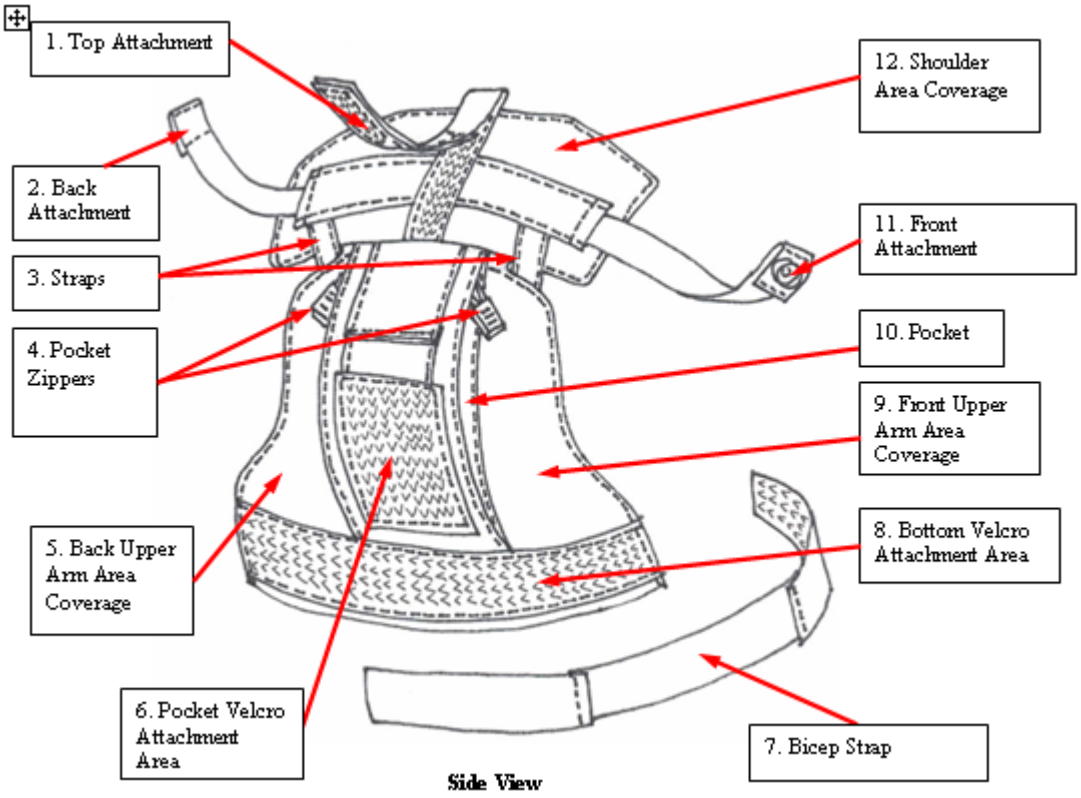
Trial Feature Questionnaires



	FUNCTIONALITY							DURABILITY						
FEATURES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Top Velcro Attachment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. Back Snap Attachment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. Front Snap Attachment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. Shoulder Area Coverage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. Velcro Pouch (on back)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Annex A:

Trial Feature Questionnaires



Side View

	FUNCTIONALITY							DURABILITY						
FEATURES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Top Attachment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. Back Attachment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. Straps	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. Pocket Zippers	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. Back Upper Arm Area Coverage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. Pocket Velcro Attachment Area	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. Bicep Strap	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8. Bottom Velcro Attachment Area	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9. Front Upper Arm Area Coverage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10. Pocket	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
11. Front Attachment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
12. Shoulder Area Coverage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Annex B: Trial Task Questionnaires

Annex B:

Trial Task Questionnaires

This page intentionally left blank.

OBSTACLE COURSE TASK:

Manoeuvrability	☹ 1 2 3	☹ 4	☺ 5 6 7
Speed of Movement	0 0 0	0	0 0 0
Agility	0 0 0	0	0 0 0
Flexibility	0 0 0	0	0 0 0
Reach	0 0 0	0	0 0 0
Overall Manoeuvrability	0 0 0	0	0 0 0
Ease of Obstacle Traverse	☹ 1 2 3	☹ 4	☺ 5 6 7
Running	0 0 0	0	0 0 0
Climbing/Descending Ladders	0 0 0	0	0 0 0
Traversing Ladder	0 0 0	0	0 0 0
Crawling	0 0 0	0	0 0 0
Climbing Low Wall	0 0 0	0	0 0 0
Forward Roll	0 0 0	0	0 0 0
Over/Under	0 0 0	0	0 0 0
Mouse Hole	0 0 0	0	0 0 0
Overall Ease of Traverse	0 0 0	0	0 0 0
Comfort	☹ 1 2 3	☹ 4	☺ 5 6 7
Fit	0 0 0	0	0 0 0
Weight	0 0 0	0	0 0 0
Bulk	0 0 0	0	0 0 0
Pressure Points	0 0 0	0	0 0 0
Chaffing	0 0 0	0	0 0 0
Overall Physical Comfort	0 0 0	0	0 0 0
Overall Thermal Comfort	0 0 0	0	0 0 0
Overall Task Performance	0 0 0	0	0 0 0

Range of Motion	☹ 1 2 3	☹ 4	☺ 5 6 7
Neck Forward/Back	0 0 0	0	0 0 0
Neck Side to Side	0 0 0	0	0 0 0
Raising Arms up	0 0 0	0	0 0 0
Moving Arms to Front/Back	0 0 0	0	0 0 0
Waist Bending Forward/Back	0 0 0	0	0 0 0
Waist bending Side to Side	0 0 0	0	0 0 0
Twisting	0 0 0	0	0 0 0
Overall Range of Motion	0 0 0	0	0 0 0
Compatibility	☹ 1 2 3	☹ 4	☺ 5 6 7
Load Carriage	0 0 0	0	0 0 0
Helmets	0 0 0	0	0 0 0
Fragmentation vest	0 0 0	0	0 0 0
Weapons	0 0 0	0	0 0 0
Stability	☹ 1 2 3	☹ 4	☺ 5 6 7
Limb Protector Stability	0 0 0	0	0 0 0
Load Carriage Stability	0 0 0	0	0 0 0
Adjustment/Durability	☹ 1 2 3	☹ 4	☺ 5 6 7
Put On	0 0 0	0	0 0 0
Adjust Fit	0 0 0	0	0 0 0
Take Off	0 0 0	0	0 0 0
Range of Adjustments	0 0 0	0	0 0 0
Adjustment Retention	0 0 0	0	0 0 0
Durability	0 0 0	0	0 0 0
Suitability for Field Use	0 0 0	0	0 0 0

Annex B:

Trial Task Questionnaires

F&M TASK

Manoeuvrability	☹ 1	2	3	😐 4	5	6	☺ 7
Speed of Movement	0	0	0	0	0	0	0
Agility	0	0	0	0	0	0	0
Flexibility	0	0	0	0	0	0	0
Overall Manoeuvrability	0	0	0	0	0	0	0
Ease of Fire & Movement	☹ 1	2	3	😐 4	5	6	☺ 7
Running	0	0	0	0	0	0	0
Dropping to prone position	0	0	0	0	0	0	0
Crouching	0	0	0	0	0	0	0
Crawling	0	0	0	0	0	0	0
Adopting prone fire position	0	0	0	0	0	0	0
Adopting kneeling fire position	0	0	0	0	0	0	0
Adopting standing fire position	0	0	0	0	0	0	0
Sighting	0	0	0	0	0	0	0
Firing	0	0	0	0	0	0	0
Loading/Unloading	0	0	0	0	0	0	0
Accessing mags/grenades	0	0	0	0	0	0	0
Throwing grenades	0	0	0	0	0	0	0
Standing up	0	0	0	0	0	0	0
Overall F&MT Task Performance	0	0	0	0	0	0	0

Compatibility	☹ 1	2	3	😐 4	5	6	☺ 7
Load Carriage	0	0	0	0	0	0	0
Helmet	0	0	0	0	0	0	0
Frag vest	0	0	0	0	0	0	0
Gloves	0	0	0	0	0	0	0
Weapons	0	0	0	0	0	0	0
Snagging	0	0	0	0	0	0	0
Overall Compatibility	0	0	0	0	0	0	0
Limb Protector Comfort	☹			😐			☺
Fit	0	0	0	0	0	0	0
Weight	0	0	0	0	0	0	0
Bulk	0	0	0	0	0	0	0
Pressure points	0	0	0	0	0	0	0
Chaffing	0	0	0	0	0	0	0
Stiffness	0	0	0	0	0	0	0
Overall Physical Comfort	0	0	0	0	0	0	0
Overall Thermal Comfort	0	0	0	0	0	0	0
Stability	☹			😐			☺
Fragmentation Vest Stability	0	0	0	0	0	0	0
Upper Limb Protector Stability	0	0	0	0	0	0	0

		Overall Stability	0 0 0 0 0 0 0
		Overall Suitability for Field Use	0 0 0 0 0 0 0

Annex B:

Trial Task Questionnaires

MOUT TASK

Manoeuvrability	☹ 1 2 3	😐 4 5 6	☺ 7
Speed of Movement	0	0 0 0 0	0
Agility	0	0 0 0 0	0
Flexibility	0	0 0 0 0	0
Overall Manoeuvrability	0	0 0 0 0	0
Ease of MOUT Movement	☹ 1 2 3	😐 4 5 6	☺ 7
Building entry	0	0 0 0 0	0
Inside door entry	0	0 0 0 0	0
Climbing/descending ladders	0	0 0 0 0	0
Climbing/descending stairs	0	0 0 0 0	0
Passage up/down through floor/ceiling breach holes	0	0 0 0 0	0
Passage through wall breach holes	0	0 0 0 0	0
Room clearance	0	0 0 0 0	0
Adopting MOUT fire positions	0	0 0 0 0	0
Overall MOUT Task Performance	0	0 0 0 0	0
Stability	☹ 1 2 3	😐 4 5 6	☺ 7
Fragmentation Vest Stability	0	0 0 0 0	0
Upper Limb Protector Stability	0	0 0 0 0	0

Compatibility	☹ 1 2 3	😐 4 5 6	☺ 7
Load Carriage	0	0 0 0 0	0
Helmet	0	0 0 0 0	0
Frag vest	0	0 0 0 0	0
Gloves	0	0 0 0 0	0
Weapons	0	0 0 0 0	0
Snagging	0	0 0 0 0	0
Overall Compatibility	0	0 0 0 0	0
Limb Protector Comfort	☹ 1 2 3	😐 4 5 6	☺ 7
Fit	0	0 0 0 0	0
Weight	0	0 0 0 0	0
Bulk	0	0 0 0 0	0
Pressure points	0	0 0 0 0	0
Chaffing	0	0 0 0 0	0
Stiffness	0	0 0 0 0	0
Overall Physical Comfort	0	0 0 0 0	0
Overall Thermal Comfort	0	0 0 0 0	0
Overall Suitability for Field Use	0	0 0 0 0	0

Overall Stability	0 0 0 0 0 0 0

MOUNTED TASK

Manoeuvrability	☹ 1	2	3	☐ 4	5	6	☺ 7
Speed of Movement	0	0	0	0	0	0	0
Agility	0	0	0	0	0	0	0
Flexibility	0	0	0	0	0	0	0
Overall Manoeuvrability	0	0	0	0	0	0	0
Vehicle Compatibility	☹ 1	2	3	☐ 4	5	6	☺ 7
Normal Access	0	0	0	0	0	0	0
Normal Egress	0	0	0	0	0	0	0
Emergency Access	0	0	0	0	0	0	0
Emergency Egress	0	0	0	0	0	0	0
Ease of Driving/Operating Weapons/Turret	0	0	0	0	0	0	0
Ability to Perform all Duties	0	0	0	0	0	0	0
Overall General Vehicle Compatibility	0	0	0	0	0	0	0
Compatibility	0	0	0	0	0	0	0
Load Carriage	☹ 1	2	3	☐ 4	5	6	☺ 7
Helmet	0	0	0	0	0	0	0
Frag vest	0	0	0	0	0	0	0
Gloves	0	0	0	0	0	0	0
Weapons	0	0	0	0	0	0	0
Snagging	0	0	0	0	0	0	0
Overall Compatibility	0	0	0	0	0	0	0

Mounted Combat	☹ 1	2	3	☐ 4	5	6	☺ 7
Scanning/ covering arcs	0	0	0	0	0	0	0
Firing personal weapons	0	0	0	0	0	0	0
Changing mags, ammo boxes for C6/ ammo for C9	0	0	0	0	0	0	0
Firing M72s and 40 mms/, throwing grenades	0	0	0	0	0	0	0
Engagement of targets using pintle mount:	0	0	0	0	0	0	0
Engaging targets with vehicle weapons	0	0	0	0	0	0	0
Combat dismount	0	0	0	0	0	0	0
Overall Mounted Combat Compatibility	☹			☐			☺
Comfort	0	0	0	0	0	0	0
Fit	0	0	0	0	0	0	0
Weight	0	0	0	0	0	0	0
Bulk	0	0	0	0	0	0	0
Pressure points	0	0	0	0	0	0	0
Chaffing	0	0	0	0	0	0	0
Overall Physical Comfort	0	0	0	0	0	0	0
Overall Thermal Comfort	☹			☐			☺
Stability	0	0	0	0	0	0	0
Fragmentation Vest Stability	0	0	0	0	0	0	0
Upper Limb Protector Stability	0	0	0	0	0	0	0
Overall Stability	0	0	0	0	0	0	0

Annex B:

Trial Task Questionnaires

Overall Task Performance	0 0 0 0 0 0 0	Overall Suitability for Field Use	0 0 0 0 0 0 0

Annex B:
Trial Task Questionnaires

This page intentionally left blank.

Annex C: Trial Discomfort Questionnaires

Annex C:

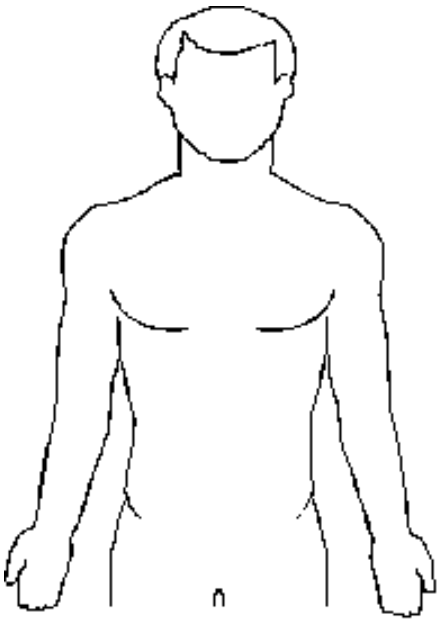
Trial Discomfort Questionnaires

This page intentionally left blank.

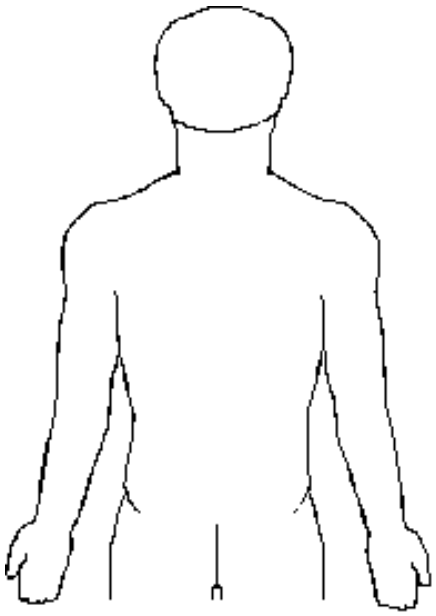
PHYSICAL DISCOMFORT

Using the different views of the shoulder, torso and arm below, draw in the areas where you felt physical discomfort. Indicate how much discomfort with a number from the scale to the right.	**Neutral** **1**	**Slight Discomfort** **2**	**Noticeable Discomfort** **3**	**Pain** **4**	**Extreme Pain** **5**

FRONT



BACK



Rate the following aspects of physical comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Pressure Points while Stationary	O	O	O	O	O	O	O
Pressure Points while Moving	O	O	O	O	O	O	O
Chaffing	O	O	O	O	O	O	O
OVERALL PHYSICAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**
COMMENTS:							

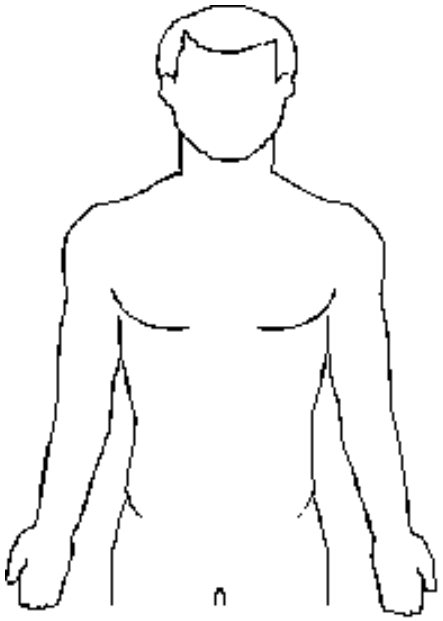
Annex C:

Trial Discomfort Questionnaires

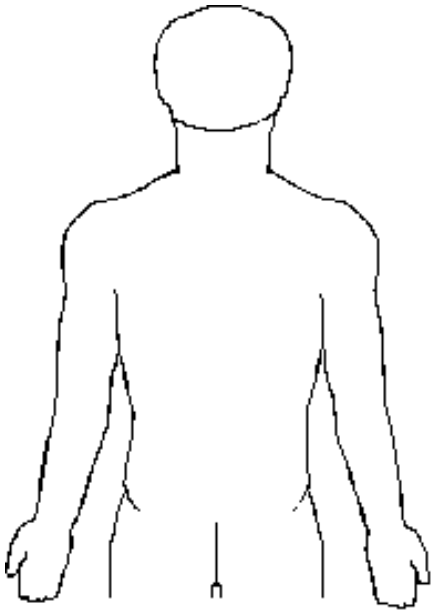
THERMAL DISCOMFORT

Using the different views of the torso below, draw in the areas where you might feel thermal discomfort. Indicate how much discomfort with a number from the scale to the right.	Neutral 1	Slightly Warm 2	Noticeably Warm 3	Hot 4	Very Hot 5

FRONT



BACK

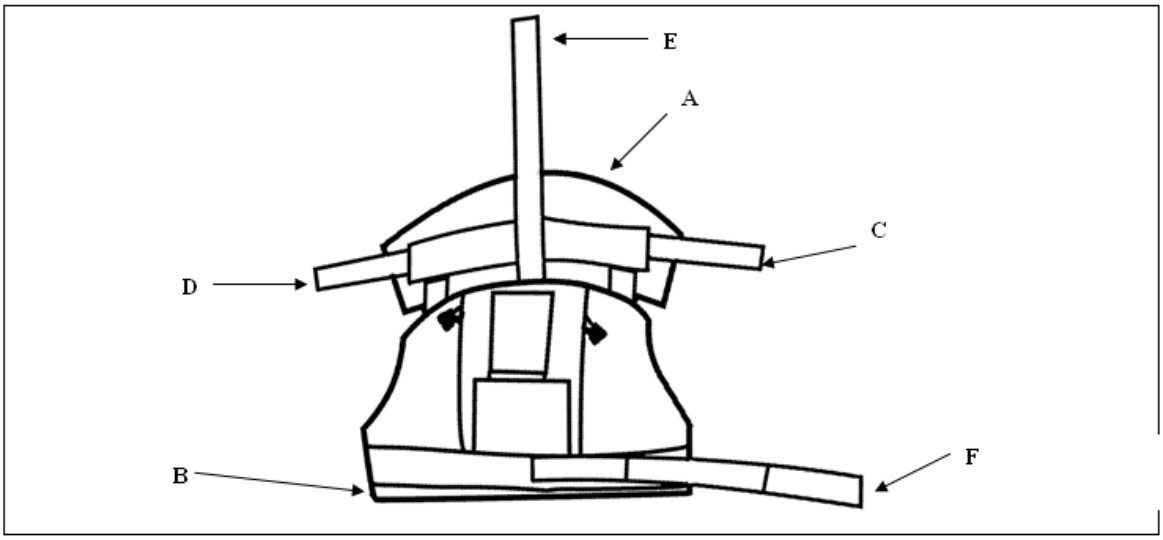


Rate the following aspects of thermal comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Hot Spots	O	O	O	O	O	O	O
Ventilation	O	O	O	O	O	O	O
OVERALL THERMAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMMENTS:

Annex D: Trial Fit Questionnaires

SIZE OF BRASSARD ISSUED:				S				M	L		
	Fit Acceptance							Fit Sizing			
Rate the fit in the following dimensions:	1	2	3	4	5	6	7	Short Small Tight			Long Large Loose
Brassard Length	O	O	O	O	O	O	O	O	O	O	O O
Brassard Girth	O	O	O	O	O	O	O	O	O	O	O O
Opening at Shoulder (A)	O	O	O	O	O	O	O	O	O	O	O O
Opening near Elbow (B)	O	O	O	O	O	O	O	O	O	O	O O
Strap Length – Front (C)	O	O	O	O	O	O	O	O	O	O	O O
Strap Length – Back (D)	O	O	O	O	O	O	O	O	O	O	O O
Main Attachment Strap (E)	O	O	O	O	O	O	O	O	O	O	O O
Bicep Strap (F)	O	O	O	O	O	O	O	O	O	O	O O
FINAL FIT	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O O**
Ease of Adjustment	O	O	O	O	O	O	O				
Ease of Donning	O	O	O	O	O	O	O				
Ease of Doffing	O	O	O	O	O	O	O				



Comment

Annex D:

Trial Fit Questionnaires

This page intentionally left blank.

Annex E: Trial Exit Questionnaires

Annex E:

Trial Exit Questionnaires

This page intentionally left blank.

Annex E:

Trial Exit Questionnaires

Daily exit questionnaire

Rate the following Features	User Acceptance Rating ☹ 1	2	3	😐 4	5	6	☺ 7
Initial Fit	0	0	0	0	0	0	0
Fit Retention	0	0	0	0	0	0	0
Donning/Doffing	0	0	0	0	0	0	0
Overall Ease of Adjustment	0	0	0	0	0	0	0
• **Ease of Adjustment in Vehicle**	0	0	0	0	0	0	0
• **Ease of Adjustment in Dismounted**	0	0	0	0	0	0	0
• **Adjustment Retention**	0	0	0	0	0	0	0
Snagging in the vehicle	0	0	0	0	0	0	0
Snagging while dismounted	0	0	0	0	0	0	0
Shoulder Coverage	0	0	0	0	0	0	0
Upper Arm Coverage	0	0	0	0	0	0	0
Shoulder Range of Motion	0	0	0	0	0	0	0
Ease of Use as a System	0	0	0	0	0	0	0
Features Acceptance (pockets, etc.)	0	0	0	0	0	0	0

Annex E:

Trial Exit Questionnaires

Final Exit Questionnaire

Rate the following Features	In-service shoulder caps							Brassard						
	☹			😐			☺	☹			😐			☺
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Fit	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fit adjustment(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Adjustment retention	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stability	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Security / Retention	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical comfort:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thermal comfort	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ease of use – attaching and removing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Snagging	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flexibility	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulk	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ease of movement (with)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Weight	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coverage	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compatibility with clothing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compatibility with equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compatibility with weapons	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compatibility with vehicles	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Rate the following Features	In-service shoulder caps							Brassard						
	☹			😐			☺	☹			😐			☺
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Compatibility with dismounted	0	0	0	0	0	0	0	0	0	0	0	0	0	0

combat tasks														
Compatibility with mounted combat tasks	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compatibility with general support tasks	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feature set	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintainability	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Durability	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suitability for operations	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OVERALL SYSTEM RATING	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex F: Statistical Test Results

Annex F:
Statistical Test Results

This page intentionally left blank.

Annex F:

Statistical Test Results

C7/C8 Live fire Statistical test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Live fire non para format. sta ANOVA Chi Sqr. (N = 24, df = 1) = 7.142857 p < .00753 Coeff. of Concordance = .29762 Aver. rank r = .26708			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Range of adjustments	1.708333	41.00000	5.833333	0.916831
range of adj sc	1.291667	31.00000	5.333333	1.090140

Obstacle Course Statistical test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Obstacle Course non para.sta) ANOVA Chi Sqr. (N = 20, df = 1) = 4.500000 p < .03390 Coeff. of Concordance = .22500 Aver. rank r = .18421			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Bulk	1.350000	27.00000	5.750000	0.910465
NewVar	1.650000	33.00000	6.200000	0.523148

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Obstacle Course non para.sta) ANOVA Chi Sqr. (N = 20, df = 1) = 7.000000 p < .00815 Coeff. of Concordance = .35000 Aver. rank r = .31579			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Overall Thermal	1.325000	26.50000	5.650000	0.875094
NewVar	1.675000	33.50000	6.150000	0.366348

Dismounted Section Fire and Movement Statistical test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Fire and Move non pai ANOVA Chi Sqr. (N = 19, df = 1) = 5.444444 p < .01963 Coeff. of Concordance = .28655 Aver. rank r = .24691			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Chaffing	1.315789	25.00000	5.842105	0.602140
NewVar	1.684211	32.00000	6.368421	0.495595

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Fire and Mov ANOVA Chi Sqr. (N = 19, df = 1) = 8.000000 p < .00468 Coeff. of Concordance = .42105 Aver. rank r = .38889			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Overall thermal comfort	1.289474	24.50000	5.631579	0.683986
NewVar	1.710526	32.50000	6.157895	0.374634

Annex F:

Statistical Test Results

Dismounted Section FIBUA Statistical test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (FIBUA non para.sta) ANOVA Chi Sqr. (N = 21, df = 1) = 6.000000 p < .01431 Coeff. of Concordance = .28571 Aver. rank r = .25000			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Chaffing SC	1.357143	28.50000	5.952381	0.497613
Chaffing brassard	1.642857	34.50000	6.333333	0.577350

Daily exit Questionnaire Statistical test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Daily Exit nonparaformat.sta) ANOVA Chi Sqr. (N = 20, df = 1) = 13.23529 p < .00027 Coeff. of Concordance = .66176 Aver. rank r = .64396			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Shoulder Coverage S	1.125000	22.50000	4.800000	1.361114
Brassard Shoulder C	1.875000	37.50000	6.400000	0.598243

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Daily Exit nc ANOVA Chi Sqr. (N = 21, df = 1) = 14.22222 p < .00016 Coeff. of Concordance = .67725 Aver. rank r = .66111			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Upper Arm Coverage	1.119048	23.50000	4.285714	1.677583
Brassard upper arm (	1.880952	39.50000	6.380952	0.589592

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Daily Exi ANOVA Chi Sqr. (N = 19, df = 1) = 4.000000 p < .04550 Coeff. of Concordance = .21053 Aver. rank r = .16667			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Features Acceptance	1.289474	24.50000	5.105263	1.370107
Brassard features acceptance	1.710526	32.50000	5.736842	1.240166

Annex F:

Statistical Test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Daily E ANOVA Chi Sqr. (N = 19, df = 1) = 4.454545 p < .03481 Coeff. of Concordance = .23445 Aver. rank r = .19192			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Compat w/ driving	1.315789	25.00000	5.789474	0.713283
Brassard driving compa	1.684211	32.00000	6.210526	0.630604

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Daily Exit nonp ANOVA Chi Sqr. (N = 18, df = 1) = 7.363636 p < .00666 Coeff. of Concordance = .40909 Aver. rank r = .37433			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Suit. For Crawling	1.250000	22.50000	5.444444	0.855585
Brassard suit. for crawling	1.750000	31.50000	5.888889	0.900254

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Daily ANOVA Chi Sqr. (N = 17, df = 1) = 4.500000 p < .03390 Coeff. of Concordance = .26471 Aver. rank r = .21875			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Ability to move in tight quarters	1.32352	22.5000	5.17647	1.01459
Brassard ability to move in tight C	1.67647	28.5000	5.82352	0.63593

Final Exit Questionnaire Statistical test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Final Exit Ques nonparaformat.sta) ANOVA Chi Sqr. (N = 21, df = 1) = 5.333333 p < .02092 Coeff. of Concordance = .25397 Aver. rank r = .21667			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Fit SC	1.309524	27.50000	5.714286	0.560612
Fit Brassard	1.690476	35.50000	6.095238	0.624881

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Final Exit Ques nonparaformat.sta) ANOVA Chi Sqr. (N = 20, df = 1) = 7.117647 p < .00763 Coeff. of Concordance = .35588 Aver. rank r = .32198			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Fit adjustment SC	1.225000	24.50000	5.300000	0.801315
Fit adj Brassard	1.775000	35.50000	5.800000	0.767772

Annex F:

Statistical Test Results

Variable	Average Rank	Sum of Ranks	Mean	Std.Dev.
Friedman ANOVA and Kendall Coeff. of Concordance (Final Exit Ques nonparaformat.st				
ANOVA Chi Sqr. (N = 21, df = 1) = 6.400000 p < .01141				
Coeff. of Concordance = .30476 Aver. rank r = .27000				
Stability SC	1.309524	27.50000	5.380952	0.920662
Stability brassard	1.690476	35.50000	5.952381	0.589592

Variable	Average Rank	Sum of Ranks	Mean	Std.Dev.
Friedman ANOVA and Kendall Coeff. of Concordance (Final E				
ANOVA Chi Sqr. (N = 21, df = 1) = 9.307692 p < .00228				
Coeff. of Concordance = .44322 Aver. rank r = .41538				
Thermal comfort SC	1.761905	37.00000	6.142857	0.654654
Brassard thermal comfort	1.238095	26.00000	5.476190	0.872872

Variable	Average Rank	Sum of Ranks	Mean	Std.Dev.
Friedman ANOVA and Kendall Coeff. of Concordance (Final Exit Ques nonp				
ANOVA Chi Sqr. (N = 21, df = 1) = 4.500000 p < .03390				
Coeff. of Concordance = .21429 Aver. rank r = .17500				
Ease of use SC	1.642857	34.50000	5.952381	0.804748
Brassard ease of use	1.357143	28.50000	5.619048	0.669043

Variable	Average Rank	Sum of Ranks	Mean	Std.Dev.
Friedman ANOVA and Kendall Coeff. of Concordance (Final Exit Ques nonparafor				
ANOVA Chi Sqr. (N = 21, df = 1) = 20.00000 p < .00001				
Coeff. of Concordance = .95238 Aver. rank r = .95000				
Coverage SC	1.023810	21.50000	3.857143	1.195229
Brassard covera	1.976190	41.50000	6.047619	0.589592

Annex F:

Statistical Test Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Final Exit Ques ANOVA Chi Sqr. (N = 20, df = 1) = 8.333333 p < .00389 Coeff. of Concordance = .41667 Aver. rank r = .38596			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Feature set	1.250000	25.00000	5.000000	0.973329
Brassard featı	1.750000	35.00000	5.850000	0.988087

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Final E ANOVA Chi Sqr. (N = 20, df = 1) = 7.363636 p < .00666 Coeff. of Concordance = .36818 Aver. rank r = .33493			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Suitability for operations	1.275000	25.50000	5.350000	1.089423
Suitability for operations Brassard	1.725000	34.50000	6.100000	0.447214

Variable	Friedman ANOVA and Kendall Coeff. of Concordance ANOVA Chi Sqr. (N = 21, df = 1) = 11.26667 p < .0007 Coeff. of Concordance = .53651 Aver. rank r = .51333			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Overall acceptance SC	1.190476	25.00000	5.238095	0.830949
Overall acceptance Bra	1.809524	38.00000	5.952381	0.497613

DOCUMENT CONTROL DATA
(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document, Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's document, or tasking agency, are entered in section 8.)

Publishing: DRDC Toronto — Lt Chris Kotscha, 1133 Sheppard Avenue West, Toronto ON M3K 2C9

Performing: Paul G. Santos Vilhena, Chris Ste−Croix and Harry A. Angel, Humansystems® Incorporated

Monitoring:

Contracting:

2. SECURITY CLASSIFICATION
(Overall security classification of the document including special warning terms if applicable.)

UNCLASSIFIED

3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title)

Evaluation of a Shoulder Fragmentation Protection Brassard Design (U)
(U)

4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.)

G. Santos Vilhena, Chris Ste−Croix and Harry A. Angel

5. DATE OF PUBLICATION (Month and year of publication of document.)	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)	6b. NO. OF REFS (Total cited in document.)
March 2008	101	6

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Contract Report

8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development − include address.)

Sponsoring: DLR 5. NDHQ 101 Colonel By, Ottawa, ON K1A 0K2

Tasking:

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
	7989−07

10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document)	10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)
DRDC Toronto CR 2008−115	

11. DOCUMENT AVAILABILITY (Any limitations on the dissemination of the document, other than those imposed by security classification.)

Unlimited distribution

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11), However, when further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Unlimited announcement

DOCUMENT CONTROL DATA
(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

(U) A fit and confirmatory design trial was conducted at Canadian Forces Base Petawawa May 28 to June 1 2007 to evaluate the differences between the current shoulder cap and brassard shoulder fragmentation protection designs. Twenty−five regular force personnel from 3rd Royal Canadian Regiment and 2nd Field Ambulance were required to undertake a battery of human factors tests while wearing the current shoulder cap and brassard conditions in a balanced, repeated measures design. A progressive four−day testing protocol was used, from static anthropometric measurements, to live fire, to dynamic discrete military activities tests, and finally a dynamic military battle task tests. Evaluations included live fire range, obstacle course, mounted fighting task, dismounted fire and movement, FIBUA, and compatibility testing. Participants rated the designs in terms of manoeuvrability, ease, stability, compatibility, and comfort. Data collection included live fire target performance, acceptability ratings after each task, thermal discomfort ratings, physical discomfort ratings, fit sizing ratings, exit questionnaire acceptability ratings, and guided focus group discussions. Overall, no highly meaningful significant differences between the two conditions were seen in target engagement performance, compatibility, or task acceptability ratings for different tasks carried out in this trial. It is recommended that brassard should be implemented for improved shoulder fragmentation protection. Design improvements to the brassard design are discussed in the report.

(U) Un essai de confirmation et d'ajustement a été effectué à la Base des Forces canadiennes Petawawa du 28 mai au 1er juin 2007 afin d'évaluer les différences entre l'épaulière pare−éclats existante et les deux modèles de brassard. On a demandé à vingt−cinq membres de la force régulière du 3e Bataillon du Royal Canadian Regiment et de la 2e Ambulance de campagne de se soumettre à une batterie d'essais des facteurs humains en portant l'épaulière actuelle et les deux modèles de brassard selon une formule équilibrée de mesures répétées. On a utilisé un protocole d'essais progressifs de quatre jours, consistant en des mesures anthropométriques statiques, des essais de tir réel, des essais dynamiques de différentes activités militaires et enfin, des essais dynamiques de tâches militaires au combat. Les évaluations ont compris des essais de tir réel, le parcours du combattant, des tâches de combat embarqué, des essais de tir à pied et des déplacements, des essais de combat dans les zones bâties, et, enfin, des essais de compatibilité. Les participants ont coté les modèles sur les plans de la maniabilité, de l'aisance, de la stabilité, de la compatibilité et du confort. Les données recueillies englobaient les mesures du rendement pendant les essais de tir réel, les cotes d'acceptabilité après chaque tâche, les cotes d'inconfort thermique et physique, les cotes d'évaluation de l'ajustement et les cotes d'acceptabilité selon le questionnaire de départ et les discussions dirigées. Dans l'ensemble, aucune différence significative n'a été constatée entre les cotes attribuées aux deux modèles de brassard sur le plan du rendement sur le champ de tir, de la compatibilité ou de l'acceptabilité pour l'exécution des tâches. Il est recommandé que le brassard soit utilisé pour améliorer la protection de l'épaule contre les éclats. Des améliorations de la conception du brassard sont présentées ci−après.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) Shoulder protection, shoulder Brassard, Brassard, Shoulder fragmentation